POWER SYSTEM COMMUNICATIONS:

Guide Specification for Mobile Radio System

REA BULLETIN 66-13

RURAL ELECTRIFICATION ADMINISTRATION • U.S. DEPARTMENT OF AGRICULTURE
JANUARY 1981

REA BULLETIN 66-13

POWER SYSTEM COMMUNICATIONS:

GUIDE SPECIFICATION FOR MOBILE RADIO SYSTEM

RURAL ELECTRIFICATION ADMINISTRATION
U.S. DEPARTMENT OF AGRICULTURE

FOREWORD

This Guide Specification has been developed to acquaint the REA Borrowers and their consulting engineers with the essential elements of a properly prepared specification for the procurement of a Mobile Radio Communications System. It is not intended to be mandatory in structure but rather, it should be used as a tutorial tool and guide in determining what is needed.

It is incumbent upon the user to add, delete and modify as appropriate for the particular system to be procured in conjunction with specific Borrowers' requirements.

Index:

TABLE OF CONTENTS

International System of Units

In December 1975, Congress passed the "Metric Conversion Act of 1975." This Act declares it to be the policy of the United States to plan and coordinate the use of the metric system.

The metric system, designated as the International System of Units (SI), is presently used by most countries of the world. The system is a modern version of the meter, kilogram, second, ampere (MKSA) system which has been in use for years in various parts of the world.

To promote greater familiarization of the metric system in anticipation of the U.S. converting to the system, REA is including metric units in its publications. This bulletin has, therefore, been prepared with the International System of Units (SI) obtained from ANSI Z 210-1976 - Metric Practice. Approximately equivalent Customary Units are also included to permit ease in reading and usage, and to provide a comparison between the two systems.

1.0 USE OF THIS GUIDE SPECIFICATION

1.1 Purpose

The intent of this bulletin is to provide an insight into the basic content requirements for the preparation of a sound, meaningful, and effective system design, engineering, and procurement specification for a Mobile Radio Communications System.

The Guide Specification is not intended as the solution for total system specification preparation; it is as the title suggests, an aid to those Borrowers who find it necessary to establish definitive specifications to be used by potential bidders. It is emphasized that the bulletin is not directive in nature; rather, its information and its purpose is to aid and supplement that information already available to Borrowers. In this regard, where the word "shall" appears, it is intended to represent the Borrower's expression to the potential bidder.

1.2 Scope

The Guide Specification covers each of the elements potentially requiring contractor assistance in the establishment of a Mobile Radio Communications System. This total system coverage permits the Borrower to use all or part of the content, dependent on support required. In addition, to covering the various inter-related system elements, the guide provides methods for obtaining contractor or consultant response to Borrower requirements as well as technical specification outlines. This guide provides only the framework for a professional and effective specification, but does not obviate the need for definitive engineering data and professional engineering effort. Indeed, this guide is not intended to be a substitute for thorough system planning and detailed engineering and design. Users of this bulletin must recognize that a thorough knowledge of system requirements must be attained before the bulletin is applied and that this knowledge is a product of adequate analysis and engineering effort. The scope of these activities are not explicitly addressed but their necessity is presumed to be understood.

1.3 Application

As earlier indicated, the contents of the bulletin are designed to permit their use in whole or in part. The solicitation instructions and attendant data (Section 2.0, 3.0 and 4.0) are pertinent to interface with potential bidders and/or with consulting engineers as requirements dictate. In effect, the bulletin content permits a "cut and paste" capability for initial preparation of the system specification framework. The word "framework" is used advisedly to emphasize the essentiality of engineering input to the final package.

Users of this bulletin are advised to be alert to the impact a parameter specified at one point in the system may have on a parameter value at another point in the system. Borrower Engineers or Consulting Engineers are the obvious source of the data necessary to fill the blanks. The fill data is the critical information which will insure that each element of the total system meets the parameters essential to system realization, construction, operation, performance, continuity, and maintenance. Firm, definitive data in the basic specification will insure that eventual contractors are technically and legally responsible for the desired results. Delays in system completion caused by insufficient or ambiguous data and the attendant discussions or renegotiations with bidders or eventual contractors, can be avoided by thorough and professional preparation of the specification. It is reiterated that the Guide Specification is only as valuable as the engineering input to the specification. Proper use and application will greatly aid the Borrower in the timely development of a Mobile Radio Communications System Specification, and serve to expedite any review and approval that may be required of the specification by Rural Electrification Administration.

2.0 SOLICITATION INSTRUCTIONS AND NOTICE TO OFFERORS

2.1 You are invited to submit to (Cooperative Name) _____ (hereafter called the "Purchaser") your proposal for the provision and delivery, F.O.B., to the locations indicated, to include installation of equipment and materials specified, which are to be part of the project known as the _____ Mobile Radio Communications System, to be financed and accomplished via a financing agreement between the Purchaser and the United States of America (hereafter called the "Government") executed by the Administrator of the Rural Electrification Administration (hereafter called the "Administrator").

Sealed Proposals, to include separate Cost Proposals, will be submitted as follows prior to _____ p.m., local time, (Date) _____.

Original and _____ copies to:

Copy to:

Proposals received or postmarked after the specified time and date shall be considered as "Non Responsive" and will not be considered unless:

- It was sent by registered or certified mail no later than the _____ calendar day prior to the date specified for receipt of offers (e.g., an offer submitted in response to this solicitation must have been mailed prior to _____ or earlier)

Acceptable evidence, as establishing proof of mailing shall be the U.S. Postal Service postmark on the wrapper, or Post Office Receipt.

2.2 Any Sub-Contractor or Material Supplier furnishing either equipment, materials or services under this project to a Prime Contractor must obtain any drawings, specifications or other documents relating to this project from its respective Prime Contractor and not from the Purchaser.

2.3 All proposals, together with other supporting documents, must be submitted on the forms furnished by the Purchaser, delivered in sealed envelopes, addressed as indicated under Paragraph 1.1 supra, with the name and address of the Offeror clearly indicated on the outside envelope containing the proposal.

Proposals must be submitted in conformance with these specifications. Should an Offeror desire to propose alternate equipment, methods in lieu of those contained in the specifications, they shall be clearly defined, and as proposed, satisfy the project requirements, and be submitted as an alternate to the basic specifications. All costs associated with an Alternate Proposal, shall be clearly defined, and furnished separate from those submitted for the basic specification requirements.

Any deviations, exceptions, or clarifications not treated in this manner shall be deemed non-compliant, and will not be considered.

2.4 The Offeror shall furnish with his proposal a complete set of specifications and typical drawings, including dimensions, design calculations and data, installation and maintenance instructions, operating characteristics, and such other information as is required to enable a thorough understanding of the equipment proposed to be furnished.

Unnecessarily elaborate brochures or other presentations beyond that sufficient to present a complete and effective proposal are not desired.

Elaborate art work, expensive paper and bindings, or other expensive visual presentation aids are neither necessary, nor wanted.

2.5 Specific information to be submitted with an Offeror's proposal shall consist of the following:

- Radio path and equipment availability and reliability calculations
- Comprehensive description of the test methods and procedures for factory and field system tests
- A project schedule showing work flow and all major items of work, emphasizing critical project items
- Appendix A, Radio Equipment Design Data
- Appendix B, Site Survey and Data Summary Sheets
- Appendix C, Link Data/Design Summary Worksheets

- List of critical and recommended spare parts for all items of equipment furnished, to include unit pieces

- List of required or recommended test equipment, to include unit pieces

- Listing of systems of similar design, complexity and operation previously furnished and installed by the Offeror, with names of organizations or persons the Purchaser may contact relative to the same

2.6 Prior to the submission of the proposal, the Offeror shall make and shall be deemed to have made a careful examination of the plans and specifications and forms of equipment contract on file in the office of the Purchaser and with the Engineer, and all other matters that may affect the cost and the time of completion of the work.

2.7 Within _____ days of receipt of this request for proposals, all perspective Offerors shall notify the Purchaser of their intent to bid. This notice shall be addressed to:

If desired by an Offeror, arrangements for a pre-submission meeting with the Purchaser will be made, to meet at the above location for discussion in reference to these specifications.

2.8 All proposals shall be signed by an individual authorized to bind the Offeror, and shall contain a statement that the proposal and Cost Quotations are valid for a period of not less than _____ days after the closing date to provide for proposal evaluation and resolution.

2.9 Any items which are clearly necessary for satisfactory performance shall be considered as part of the contract even though not directly specified. Such items should be noted by the Offeror and included in his proposal response.

2.10 Within _____ days after notice of award is given to the successful Contractor, a conference will be held in the office of the Purchaser for the purpose of discussing the details of the system equipment to be furnished and the schedule and manner in which the manufacturer's drawings are to be prepared and submitted. The Offeror shall have present at this meeting, the project engineer responsible for this project.

2.11 Any exception to those specifications must be clearly indicated by the Offeror using the following format:

a. Paragraph number

b. Exception taken and reason

c. Suppliers recommendations, substitution, or alternative

2.12 The contract, when executed, shall be deemed to include the entire agreement between the parties thereto, and the Offeror shall not claim any modification thereof, resulting from any representation or promise made at any time, by an officer, agent, or employee of the Purchaser or by any other person.

The Purchaser reserves the right to reject any or all proposals.

_____
(Cooperative Name)

_____ BY: _____
DATE

3.0 CONTRACT FORMS

The appropriate REA standard contract forms should be used. Usually, these forms will adequately express the intent of the parties to the contract. However, some modification of the standard form may be required in order to obtain the detailed description of services and work needed for a specific undertaking. When contemplating such changes, care should be exercised to prevent those changes from relieving the contractor of any of the responsibilities required of the REA standard form.

4.0 SCOPE OF PROJECT

This section should provide the qualitative information about the project that places it in clear perspective and, together with the detailed specifications, leads to as complete an understanding of the mission to be accomplished as practicable. This information should be in the form of a comprehensive summary that provides a general overview of the system, its objectives and requirements, equipment to be supplied, and a clear indication of the system's size and complexity. Information supplied should be concise, but, at the same time, in sufficient depth to ensure the quality of bids to be received.

Clear functional information about the system should be included. Uncertainty about the functional requirements can translate into additional system costs because increased flexibility must be designed into the system. While flexibility may be desirable if it can be obtained at little cost, it is often costly in terms of available resources and obtained at the expense of other valuable features. Functional information about the system should include terminal and repeater locations, spur branching points, direction of information flow and the type of information to be transmitted, channel types and quality, compatibility with existing equipment and services, and capability for expansion.

5.0 MOBILE RADIO SYSTEM REQUIREMENTS

5.1 General

The system shall be a mobile relay type operating in the ____ to ____ MHz range. Specific operating frequencies will be assigned based upon final FCC construction permit. The system shall use _____ mobile relay stations. These mobile relay stations are located throughout the service area. Each bidder shall analyze the propogation and mobile coverage from the sites. The bidder will indicate the percentage of service area covered along with the service probability in terms of time.

5.2 Control Stations

There will be _____ control stations located at the member distribution cooperative headquarters. It is necessary that these units be able to access the nearest mobile relay station and will encode (transmit) the tone signal assigned to that mobile relay. The receiver shall decode a single tone transmitted either by a mobile unit through the mobile relay station or through the mobile relay via the control center console.

5.3 Mobile Relay Station

Mobile relay stations shall employ (CTCSS) tone signals. The mobile relays will all transmit (encode) the same sub-audible (CTCSS) tone. The different mobile relays will receive (decode) various sub-audible (CTCSS) tones. A total of _____ tones will be assigned to the various mobile relay receivers. Since there are _____ mobile relays, assignment will be made on the basis of distance between mobile relay stations.

5.4 Mobile Units

The mobile units shall also have sub-audible (CTCSS) tone coded squelch. The mobile units will decode the common tone that is encoded by all mobile relay stations. The mobile units shall have multiple sub-audible encoding capability. These units shall be able to encode _____ different (CTCSS) tones selectable from the control head. The mobile units shall have the capability to encode _____ different single tones also selectable from the control head. Mobile units shall be capable of _____ channel operation. All units shall be equipped with repeater talk around.

The vehicular repeater shall have a vehicular charger for its associated hand held mobile unit. The vehicular hand held charger shall be directly interconnected to the vehicular repeater such that when the hand held portable is removed from the charger, the vehicular repeater shall be automatically enabled, when the hand held portable is replaced in the charger the vehicular repeater shall be automatically disabled. There shall be a manual override switch to disable vehicular repeater when hand held is removed from charger.

5.5 Alarm and Control System

The system shall also employ a radio controlled alarm and control system. The primary function of this system is to control (open-close) line switches throughout the system and to indicate status of these switches. The alarm and control system shall encode and decode the appropriate alarm and control functions using a digital word format. The central control unit shall employ a self contained control unit housing all memory functions, alarm displays, all encoding and decoding equipment and power supplies. It is desirable to have the central control unit easily installable in an existing central communications series console. The remote units will operate on an external antenna system and will access a designated mobile relay station. Both the central control unit and remote unit must comply with FCC regulations regarding secondary signaling.

5.6 Hand Held Unit

The system will include _____ hand held portable units. These units will operate in the _____ MHz range. Units shall be capable of encoding _____ sub-audibile (CTCSS) tones to access mobile relay stations. Also, they shall decode common sub-audible (CTCSS) tone transmitted by mobile relay stations. Units shall have repeater talk around capability. Units will be furnished with individual unit chargers.

5.7 Remote Control Units

Remote control units will be used at _____ locations on mobile relay stations.

5.8 Antennas and Transmission Lines

Contractor will furnish all transmission lines, connectors, wraplock, antennas, etc., necessary to complete the antenna system installation.

5.9 Responsibilities

5.9.1 The contract shall provide:

- Engineering
- Furnishing
- Material
-
-
-

5.9.2 The owner shall provide:

- License application
- Building to house equipment
- AC power source
-
-
-

6.0 BASE STATION CONTROL SYSTEM SPECIFICATIONS

6.1 General

The system will utilize control stations at _____ locations. The control unit will access the nearest mobile relay station to establish communications with the Control Center. These control stations will encode and transmit the tone signals to access the station to which they are dedicated.

6.2 Local Control System

6.2.1 General

The specifications should set forth the minimum requirements for the performance of a two-way FM radio control station which can provide adequate and reliable communications within the proposed radio system. In all details not specifically stated herein, it is understood that the equipment shall meet or exceed those requirements of the Electronic Industries Association and the Federal Communications Commission which are current at the time of the award or installation.

The radio set shall be a two-way FM base station consisting of a transmitter, receiver, and power supply in a single unit. It shall operate on specific frequencies in the _____ MHz band.

The transmitter shall be capable of intermittent operation over a _____ C to _____ C ambient temperature range.

6.2.2 Humidity Test

The equipment shall meet or exceed all specified EIA standards when subjected to high humidity in accordance with EIA Standard RS-152B, RS-204A, and RS-220.

6.2.3 Replacement Parts

The manufacturer shall maintain, provide, and recommend test equipment and replacement parts when needed. A complete parts depot shall be located in geographical proximity consistent with the most expedient method of shipping replacement parts.

An ample stock of individual components and equivalent unit replacements shall be carried for _____ years. Test equipment and tools shall be designed, tested and qualified to meet the needs of the product serviced. Calibration service shall be available on all test instruments.

6.2.4 Enclosure

The enclosure shall be formed of durable, flame-retardant plastic, suitable for desk-top or table-top mounting. The top cover shall be easily removable from the radio set and front panel for the purpose of servicing.

The enclosure shall contain no louvers or ventilating holes on its top surface, so that the radio set can be safely installed on a shelf or a confined area, and so that papers or objects placed on top of the unit will not cause the equipment to overheat.

6.2.5 Chassis/Accessibility

The transmitter, receiver, and power supply circuitry shall be mounted on, and protected by, heavy-gauge metal sub-chassis sections. These sections shall be securely fastened to form a mechanically solid unit. External heat radiators shall be used to keep the final RF amplifier within specified operating temperatures, without allowing air-borne contaminants to enter that portion of the radio's interior.

The main transmitter and receiver shall be an integral unit so mounted as to provide easy accessibility of all components for servicing as well as easy removal, when necessary.

6.2.6 Control

The unit shall be operated from a front control panel. The control panel shall include all facilities for complete operation of the equipment. There shall be suitable termination facilities for the microphone and control cables at the rear of the unit.

A Remote, ON-OFF Switch shall be included on the front panel of the radio station so that the operator may exercise "takeover" control over all other remote dispatch points, to comply with FCC Rules and Regulations. From the control panel position, the operator shall be able to monitor, and disable all transmissions made from all other dispatch points in the system.

6.2.7 Oscillator Stability

The equipment shall employ a heated quartz crystall to control the transmitter frequency. The oscillator shall maintain frequency stability within $\pm$ _____ with a primary power supply voltage variation of $\pm$ _____. A variable reactance shall be included to permit setting the oscillator to the exact operating frequency.

The receiver oscillator control shall maintain frequency stability within ± _____ of the assigned center frequency over an ambient temperature range of _____°C to _____°C and within _____% with a primary power supply voltage variation of ± _____%. Variable reactance shall be included to permit setting the oscillator to the exact operating frequency.

6.2.8 Primary Power

The power supply shall operate from a nominal _____ volt, 60 Hz primary power source, and shall furnish all transmitter and receiver operating voltages.

All semiconductor devices used in this supply shall be silicon and shall be adequately rated for optimum reliability. A finned heat exchanger shall be adequately fused to protect the radio set from damage due to overload.

The transmitter, receiver, and control facilities shall operate within EIA specification at rated voltages ± _____%, in accordance with EIA Standard RS-237, and shall be capable of starting and operating without damage to equipment at rated voltage ± _____%.

6.2.9 Current Drain

Maximum total current input to the radio set from the primary power source shall not exceed _____A in Standby and _____A in Transmit Mode.

6.3 Transmitter Characteristics

6.3.1 General

The transmitter shall comply fully with all EIA Standards and applicable FCC type acceptance Rules and Regulations. The unit shall employ solid-state circuitry throughout the transmitter.

6.3.2 Emission

The transmitter emission shall be designated _____ as defined in FCC Rules and Regulations, Part 2, Subpart C, and shall comply with all EIA Standards and FCC Rules and Regulations.

6.3.3 RF Power Output

The final RF amplifier shall deliver at least _____ watts to the output terminals of the transmitter when the output terminals are connected to a nominal output impedance of 50 ohms, in accordance with EIA Standard RS-152B.

6.3.4 Modulation

In accordance with FCC Rules and Regulations, an instantaneously acting deviation limiter circuit shall be incorporated to permit nominal 100% modulation of the transmitter under normal speech conditions, and prevent modulation in excess of 100% under extremely loud speech conditions. The limiter circuit shall have a continuously variable control to permit setting transmitter deviation to any value between 0 and maximum permissible system deviation.

6.3.5 Required Circuitry

The deviation limiter circuit shall have performance characteristics such that a _____ dB increase in audio signal input over the required for 3 KHz deviation shall not increase deviation to more than full permissible system deviation.

The deviation limiter shall continue to function as specified with input power supply variations up to ± _____%. A 1,000 Hz tone shall be used as a standard reference frequency in setting the deviation control.

6.3.6 Tone Generator

To be specified by borrower as required by system design.

6.3.7 Spurious and Harmonic Emissions

Spurious and harmonic emissions shall be attenuated below the maximum level of emissions of the carrier frequency by at least _____ dB in accordance with EIA Standards _____.

6.3.8 Input Impedance

The audio input circuit shall have nominal input impedance of _____ ohms to match standard microphone output impedance.

6.3.9 Frequency Response

Audio frequency response shall not vary more than +____, -_____ dB from a true 6 dB/octave preemphasis characteristic from 300 to 3,000 Hz as referred to the 1,000 Hz level.

6.3.10 Microphone

A dynamic microphone, complete with stand, shall be supplied as part of the equipment. A "push-to-talk" switch shall be incorporated in the base of the microphone stand. The microphone cable shall include the audio and "push-to-talk" functions.

6.3.11 Audio Distortion

Audio harmonic distortion shall not exceed ____% with a 1,000 Hz test tone at a level sufficient to produce ± 3.0 KHz deviation, in accordance with EIA Standard RS-152B.

6.3.12 Audio Sensitivity

The modulator and associated audio circuits shall exhibit sufficient sensitivity to allow 3 KHz deviation from a microphone input of _____ volt, ± dB. All audio frequencies above 3,000 Hz shall be attenuated by a post-limiter filter as prescribed by FCC Regulations.

6.3.13 FM Noise and Residual Hum

FM noise and residual hum shall be at least _____ dB below 3 KHz deviation at 1,000 Hz as measured through a standard 6 dB per octave deemphasis network.

6.3.14 AM Noise and Residual Hum

AM noise and residual hum shall be at least ____ dB when measured in accordance with EIA Standard RS-152B.

6.4 Receiver Characteristics

6.4.1 General

The receiver shall be of the _____ conversion superheterodyne type, with crystal-controlled local oscillators. The circuit shall use high quality, long-life components throughout; no tubes shall be used.

6.4.2 Selectivity

Major selectivity elements shall precede the major gain determining elements to minimize effects from signals on other channels. The major portion of the receiver rejection capabilities shall be controlled monolithic crystals in the IF section, which collectively exhibit a sharp-skirted bandpass characteristic. Selectivity characteristics, as measured in accordance with EIA Standard RS-204A and shall be at least _____ dB @ ± 25 KHz.

6.4.3 Modulation Acceptance

The modulation acceptance bandwidth of the receiver shall be at least ± _____ KHz when measured in accordance with EIA Standard RS-204A.

6.4.4 Usable (EIA-SINAD) Sensitivity

Usable sensitivity shall be at least 0.3 microvolt for a 12 dB ratio of signal-plus-noise-plus-distortion to noise-plus-distortion, in accordance with EIA Standard RS-204A.

6.4.5 Quieting Sensitivity

An "on channel" signal of 0.4 microvolt or less, when impressed across the antenna input, shall produce 20 dB of noise quieting in accordance with EIA Standard RS-204A.

6.4.6 Intermodulation Spurious Attenuation

The intermodulation spurious response attenuation at the usable sensitivity level shall be at least ____ dB when measured in accordance with EIA Standard RS-204A.

6.4.7 Spurious and Image Rejection

The spurious and image rejection shall be at least -100 dB when measured in accordance with EIA Standard RS-204A.

6.4.8 Audio

There shall be _____ audio frequency outputs with characteristics as follows, measured in accordance with EIA Standard RS-204A.

(1) Telephone Line Output
Response:

Distortion:
Hum and Noise:

(2) Speaker Output:
Response:

Distortion:
Hum and Noise:

6.4.9 RF Circuits

There shall be multiple tuned RF circuits preceding the first RF amplifier. Tunable circuitry shall be used ahead of the first RF amplifier for reduction of off-channel interference. This circuitry shall be highly selective and shall permit the reduction of interference on either the high or low side of the incoming receiver RF carrier frequency.

6.4.10 Limiters

There shall be sufficient IF limiter stages preceding the discriminator stage to reduce amplitude modulated interference.

6.4.11 Carrier Squelch Circuit

At the threshold setting, a signal of _____ microvolt or less shall provide positive squelch opening. The squelch circuit shall be designed so as not to respond to noise bursts. With an on-frequency signal at the receiver input, the squelch control set at the threshold and the audio modulation adjusted and held constant at the maximum rated system deviation, the sensitivity of the squelch circuit shall not exceed the rated threshold sensitivity as the modulating frequency is varied over the range from 300 to 3,000 Hz.

7.0 MOBILE SYSTEM SPECIFICATIONS

7.1 Mobile Relay Station

7.1.1 General

The specifications should set forth the minimum requirements for the performance of a mobile relay station which can provide adequate and reliable communications within the proposed system. It is understood that the equipment shall meet or exceed those requirements of the Electronics Industries Association and the Federal Communications Commission which are current at the time of the award or installation.

The radio set shall be constructed as a compact, highly reliable, mobile relay station consisting of a transmitter, receiver, RF isolator and power supply in cabinet. Units will be equipped with type "N" RF output connector and type "BNC" receiver input connector. An in cabinet duplexer shall be provided for transmitter-receiver isolation.

The FM two-way radio set shall be capable of operating as an unattended mobile relay station. Transmitter activation of the mobile relay shall be provided, by means of a specific continuous tone signal modulating the received carrier or by tone control from the Control Center.

An all solid state switching device shall activate the transmitter - push-to-talk circuitry whenever a carrier is detected by the receiver. The signal level at which the transmitter is keyed shall be set by a control on this squelch gate independent of the receiver squelch circuitry.

7.1.2 Humidity Tests

The equipment shall meet or exceed all governing EIA standards when subjected to high humidity tests in accordance with EIA standards RS-152B, RS-204, and RS-220.

7.1.3 Replacement Parts

The manufacturer shall provide and maintain replacement parts and recommended test equipment as needed.

7.1.4 Wire

When subjected to open flame, hot soldering iron, or short circuit, the wire used in the equipment shall not support combustion for more than five seconds after the heat source has been removed.

7.1.5 Serviceability

All parts which require periodic service or maintenance, and all tunable circuit adjustments, shall be easily accessible. The plug in circuit boards shall be secured to the radio chassis by means of captive screws wherever possible. All control and

RF modules shall be capable of being removed and replaced without clipping or soldering. Shields shall be provided for circuit boards where necessary and be fitted with a snap mechanism holding them securely in place and which allows their removal without screws or bolts. Shield and circuit boards shall be easily removable.

7.1.6 Time Out Timer

To avoid the keying of a transmitter for extended periods of time which results in channel tie-up, an automatic timer shall be included in the radio. The timer shall turn off the transmitter after a pre-set interval of 1/2, 1, 2, 4 or 8 minutes. The timer shall be automatically preset by the push-to-talk circuitry. The timer shall also be capable of selecting either repeater push-to-talk or line control push-to-talk with separate selected timing capability.

7.1.7 Power Supply

All mobile relay stations shall operate from a nominal _____ VAC 60 Hz single phase source. The power supply design shall be such that there will be no performance degradation when AC line input voltage varies over the range from -_____% to + _____%.

The power supply shall be of completely solid state design to assure maximum reliability. Current limiting shall be provided to prevent damage from overload.

7.1.8 Oscillator Stability

The equipment shall employ non-heated quartz crystals to control both the transmitter and receiver frequencies. The crystal oscillator and all compensating circuits shall be housed in a sealed, factory adjusted, plug-in module. The transmitter and receiver oscillator modules shall maintain frequency stability within _____% of the assigned center frequency with a primary power supply voltage variation of ± ____%. The transmitter oscillator module shall maintain frequency stability within ± _____% of the assigned center frequency over an ambient temperature range of -____°C to + ____°C.

The radio set receiver shall include a plug-in oscillator module capable of maintaining frequency stability within ± _____% of assigned center frequency using automatic frequency control (AFC) which will maintain automatic adjustment to compensate for carrier frequency drift, receiver frequency drift and netting errors. The receiver shall have less netting error (with reference) to discriminator oscillator over an ambient temperature range of -____°C to +____°C. The maximum frequency correction shall be limited by a barrier circuit so that the receiver cannot lock on to an adjacent channel signal ± ____ KHz from the receiver operating frequency.

7.1.9 Loudspeaker

A permanent magnet loudspeaker with associated "ON OFF" switch and volume control shall be included as an integral part of the station, to facilitate local operation, and test procedures. This speaker shall be used to monitor all receiver audio, and console audio present on the control lines. This loudspeaker shall be at least a nominal ____mm by ____mm.

7.1.10 Microphone

A microphone shall be provided for servicing the base station. The microphone shall have a dynamic element with a transistorized preamplifier built into the microphone. The microphone shall have a plug in connector to allow easy removal from the base station.

7.2 Transmitter Characteristics

7.2.1 General

The transmitter shall comply fully with all EIA Standards and FCC type acceptance Rules and Regulations applicable.

The transmitter shall be contained on a _____ meter rack mounting chassis, a unitized chassis and a power amplifier chassis. The power amplifier shall consist of a power amplifier circuit module and metering facilities. The exciter-driver section of the unitized chassis shall consist of an exciter circuit module, an interstage bandpass filter, a tripler-low-level amplifier module with bandpass filter, antenna network, and power control modules.

The power amplifier shall employ a suitable cast heat exchanger consisting of both a heat radiator and an integral mounting surface for the power amplifier transistors, to allow maximum heat transfer capability of the devices under continuous duty operation, without the use of forced-air cooling devices. The RF shield for the power amplifier shall incorporate captivated hardware for ease in servicing. From the exciter bandpass filter output to the final amplifier output, the circuitry shall be broadband design and require no tuning adjustments.

7.2.2 Transmitter Side Band Spectrum

The transmitter side band spectrum shall be at least ____ dB down at ± 25 KHz and _____ dB down at ± 1 MHz.

7.2.3 Conducted Spurious and Harmonic Emissions

Conducted spurious emissions shall be attenuated below the maximum level of emissions of the carrier frequency by at least ___ dB in accordance with EIA Standard RS-152B.

7.2.4 FM Noise and Residual Hum

FM noise and residual hum shall be at least _____ dB below ____% maximum deviation at 1,000 Hz test tone as measured through a standard 6 dB per octave deemphasis network.

7.2.5 AM Noise and Residual Hum

AM noise and residual hum shall be at least ____ dB when measured in accordance with EIA Standard RS-152B.

7.2.6 Modulation

In compliance with FCC Rules and Regulations, Part 90, Paragraph 90.211 (c), an instantaneously acting deviation limiter circuit shall be incorporated, to permit nominal 100% modulation of the transmitter under normal speech conditions, and to prevent modulation in excess of 100% under extremely loud speech conditions. A continuously variable control shall be provided to permit setting transmitter deviation to any value between 0 and maximum permissible system deviation.

7.2.7 Deviation Limiter Circuit

The deviation limiter circuit shall have performance characteristics such that a ____ dB increase in audio signal input over that required for 3.0 KHz deviation shall not increase deviation to more than full permissible system deviation. A 1,000 Hz tone shall be used as a standard reference frequency in setting the deviation control.

7.2.8 Audio Sensitivity

The modulator and associated audio circuit shall exhibit sufficient sensitivity to allow 3.0 KHz deviation from an audio input of _____V, ± 3 dB at the microphone terminal or -____ dBm at the control line terminals (remote control models). All audio frequencies above 3,000 Hz shall be attenuated by a postlimiter filter to conform with FCC regulations.

7.2.9 Audio Distortion

Audio harmonic distortion shall not exceed ____% with a 1,000 Hz test tone at a level sufficient to produce ___% deviation, in accordance with EIA Standard RS-152B.

In addition, audio distortion shall not exceed ____% for any frequency test tone from 300 to 3,000 Hz at a level sufficient to produce ____% deviation or ____% with a 1,000 Hz test tone at a level sufficient to produce ____% deviation.

7.2.10 Audio Frequency Response

Audio frequency response shall not vary more than +1, or -3 dB from a 6 dB per octave preemphasis characteristic from 300 to 3,000 Hz as referenced to the 1,000 Hz level, in accordance with EIA Standard RS-152B.

7.2.11 Power Control and Protection

The transmitter shall be equipped with an instantaneous power control such that the power output will not vary more than ____% with increasing transmitter supply voltage from EIA normal to ____%.

The transmitter shall be equipped with a VSWR detection circuit such that:

- Forward power can be metered
- Referse power can be metered
- A smooth reduction of input power occurs proportional to an improper antenna terminal termination

7.2.12 RF Power Output

The continuous duty transmitter shall be capable of operation beyond EIA continuous duty operation without degradation or damage. The transmitter shall be capable of operation at ____°C and ____% line voltage with greater than ____% of rated output power of ____ watts to the output 50 ohm termination in accordance with EIA Standards RS-152B.

The transmitter shall employ a built in isolator to protect it from various antenna termination VSWR combinations, and to reduce transmitter intermodulation. The transmitter emission shall be as defined in FCC Rules and Regulations, and shall comply with all EIA Standards and FCC Rules and Regulations.

7.3 Receiver Characteristics

7.3.1 General

The receiver shall employ only solid state circuitry and be of a _____ conversion superheterodyne type.

Major selective elements shall precede the major gain-determining elements to minimize effects from signals on other channels. The major portion of the receiver rejection capabilities shall be controlled by fixed, tuned monolithic crystal filters in the IF section, which collectively exhibit a sharp skirted bandpass characteristic.

7.3.2 Quieting Sensitivity

An "on-channel" signal of _____ microvolts or less, when impressed across the antenna input, shall produce _____ dB of noise quieting in accordance with EIA Standard RS-204A.

7.3.3 Usable (EIA-SINAD) Sensitivity

Usable sensitivity shall be at least _____ microvolts for a _____ dB ratio of signal-plus-noise-plus-distortion to noise-plus distortion, in accordance with EIA Standard RS-204A.

7.3.4 Selectivity

Selectivity characteristics shall be at least -90 dB at ± 25 KHz when measured in accordance with EIA Standard RS-204A. The receiver shall meet -100 dB desensitization at ± 1 MHz when measured in accordance with EIA Standard RS-204A.

7.3.5 Intermodulation Spurious Attenuation

The intermodulation spurious response attenuation at the usable sensitivity level shall be at least ____ dB when measured in accordance with EIA Standard RS-204A. The intermodulation spurious response attenuation at the usable sensitivity level shall be at least ____ dB when measured in accordance with EIA Standard RS-204A.

7.3.6 Spurious Response Attenuation

All spurious responses shall be attenuated at least ____dB below the on-frequency signal level which produced ____dB of noise quieting in accordance with EIA Standard RS-204A.

7.3.7 RF Circuits

Multiple tuned RF circuits shall precede the mixer for reduction of off-channel interference. This circuitry shall be highly selective, and shall be capable of reducing interference on either the high or low side of the incoming receiver RF carrier frequency.

7.3.8 Modulation Acceptance

The modulation acceptance bandwidth of the receiver shall be a minimum of + ____ KHz when measured in accordance with EIA Standard RS-204A.

7.3.9 Squelch Tail Elimination

In addition the squelch shall have a signal level detection circuit such that with input signals below ____ dB quieting the squelch operates in a normal manner and prevents closure on marginal signals or signals in flutter conditions. Above ___ dB quieting input signal levels, the squelch shall operate in a manner so that noise bursts at the end of a signal reception are less than 10 milliseconds in duration.

7.3.10 Audio Characteristics

- Telephone Line Output
- Response
- Distortion
- Hum and Noise
- Output Available for Local Speaker
- Response
- Distortion
- Hum and Noise

7.4 Mobile Units

7.4.1 General

Mobile units shall transmit and receive on a specific frequency in the _____ MHz band. The equipment shall consist

of a radio set, control unit, intercabling kit and such other items as shall be required for a complete two-way FM mobile radio installation.

The radio set shall consist of a transmitter and receiver assembly in a fully enclosed housing. No tubes shall be used in the radio. To minimize internal heat generation, the radio shall operate directly off the vehicle battery with no internal power supply. The radio set shall be designed to withstand the severe conditions encountered in mobile radio operation, and shall operate as specified throughout an ambient temperature range of ____°C to ____°C.

7.4.2 Standards

The radio set shall meet or exceed all applicable FCC requirements. All electrical tests shall be either referenced to a specific test procedure or shall be described in full by the manufacturer. The equipment shall be capable of operation without significant degradation when subject to applicable temperature, shock, humidity and vibration tests set forth in EIA Standards RS-152B and RS-204.

7.4.3 Installation

The radio set shall be capable of being easily installed in the vehicle in any suitable location, with mounting hardware furnished. The radio set shall be capable of being serviced in place without disturbing the equipment installation. All tuning adjustments shall be readily accessible from the top of the radio set by simply removing the housing cover. There shall be no screws accessible on external surfaces of the radio unit.

7.4.4 Housing

The radio set housing shall consist of a chassis with top and base cover and, a front panel. The assembled housing shall be tight fitting and shall have no louvers or other openings, so that the radio shall be protected from dust, dirt, and moisture.

Power distribution for the radio set shall be accomplished via an etched circuit control board, to limit the number of wires in the set. Modular construction should be utilized throughout the set, with a plug-in interconnection system for ease of maintenance. All modules should be removable from the radio set without clipping or unsoldering. Shields shall be provided for circuit boards where necessary, and be designed with a snap mechanism to hold them firmly in place and allow their removal without screws or bolts. Shields and circuit boards shall have handles provided to facilitate removal.

The radio set main power connector shall be securely mounted to the front panel, and recessed in the panel to prevent damage to the contacts. The power connector shall have at least ___ additional contacts to provide maximum flexibility for future field installation of options or accessory equipment.

All dc switching shall be accomplished by the use of hermetically sealed reed switches or transistors to eliminate contamination from dust, dirt, water, and corrosive atmosphere. Voltage regulation shall be provided for all critical gain sensitive or frequency sensitive circuits in the receiver and transmitter. All transistor devices in the radio shall be silicon.

The radio shall have provision for plugging in, without soldering or rewiring, an optional transmitter timer which shall turn the transmitter off so that accidental prolonged transmitter keying cannot cause repeater "lock-up" or channel pre-emption.

7.4.5 Operational Tests and Adjustment

An auxiliary control and metering socket shall be incorporated within the radio set to provide control functions so that a suitable test set can operate the radio at the point of installation.

Metering of all essential circuits should be possible while the radio is installed and operating within the vehicle. These essential circuits shall be conveniently accessible via means of centralized metering sockets on the circuit boards of the receiver, transmitter exciter, and power control circuit. The metering socket on the power control circuit board shall include a means of measuring both forward and reverse antenna power.

7.4.6 Primary Power Requirements

The radio set shall operate from a nominal 12 volt negative ground dc source. Provisions shall be made to accommodate 12 V positive ground vehicular voltages through the addition of an optional "positive ground kit" which shall automatically convert the radio to permit positive ground operation and still retain a simultaneous negative ground operation capability.

7.4.7 Reverse Polarity Protection

The radio shall be protected by fuses and circuitry so that no damage will occur if the radio is accidentally connected to a power source of the wrong polarity. This protection shall apply whether the radio is in the transmit or receive condition.

7.4.8 Receiver Frequency Stability

The receiver frequency stability shall be determined by non-heated quartz crystals. The crystal, oscillator and all compensating circuits shall be housed in a sealed, factory adjusted, plug-in module to assure precise frequency control. An automatic frequency control circuit (AFC) shall be incorporated, which will maintain automatic frequency adjustment to compensate for carrier frequency drift, receiver frequency drift and netting errors. Receiver frequency

stability shall be ± _____% from _____°C to _____°C. The maximum frequency correction shall be limited by a "barrier circuit" so that the receiver cannot "lock on" to the adjacent channel signal.

7.4.9 Transmitter Frequency Stability

The transmitter frequency stability shall be predominantly determined by the frequency stability of the oscillator module for the transmit/receive frequency pair. The transmitter crystal oscillator shall use non-heated quartz crystals. The transmitter frequency stability shall be maintained within ± _____% of the assigned center frequency over an ambient temperature range of ____° C to ____°C.

7.4.10 Transmitter Characteristics

7.4.10.1 General

The transmitter shall comply fully with all EIA Standards and applicable FCC type acceptance Rules and Regulations. The unit shall employ only solid state circuitry and shall operate directly from the vehicle battery with no power supply.

The transmitter shall utilize circuitry which senses forward power, reverse power, and heat sink temperatures to protect the transistors from overload conditions caused by excessive temperature or by mistuned antenna conditions. This circuit shall automatically adjust the operating power input of the transmitter to a level sufficient to allow continuing communications while maintaining safe operating conditions for the power amplifier transistors.

7.4.10.2 Antenna Switching Network

The transmitter should be equipped with an antenna switching network which will connect the transmitter power amplifier output to the antenna during transmit and the receive pre-selector input to the antenna during receive mode.

7.4.10.3 Emission

The transmitter emission shall be ____ and ____ as defined in FCC Rules and Regulations, part 2, subpart C and shall comply with all EIA Standards and FCC Rules and Regulations as applicable.

7.4.10.4 RF Power Output

Under intermittent duty, the transmitter shall deliver at least ___ watts to the output terminals of the transmitter when the output terminals are connected to a nominal output impedance of 50 ohms, to comply with EIA Standard RS-152B.

7.4.10.5 Conducted Spurious and Harmonic Emissions

Conducted spurious emissions shall be attenuated below the maximum level of emissions of the carrier frequency by at least ____dB to comply with EIA Standard RS-152B.

7.4.10.6 FM Noise and Residual Hum

FM noise and residual hum shall be at least ___ dB below ____% maximum deviation at 1,000 Hz test tone as measured through a standard 6 dB per octave deemphasis network.

7.4.10.7 AM Noise and Residual Hum

AM noise and residual hum shall be at least _____ dB when measured as prescribed in EIA Standard RS-152B.

7.4.10.8 Modulation

In accordance with FCC Rules and Regulations, Part 90, Paragraph 90.211 (c), an instantaneously acting deviation limiter circuit shall be incorporated to permit nominal 100% modulation of the transmitter under normal speech conditions, and to prevent modulation in excess of 100% under extremely loud speech conditions. A continuously variable control shall be provided to permit setting transmitter deviation to any value up to the maximum permissible system deviation.

7.4.10.9 Audio Sensitivity

The modulator and associated audio circuits shall exhibit sufficient sensitivity to allow a 3.0 KHz deviation from a microphone input of _____ volt, ± 3 dB. All audio frequencies above 3,000 Hz shall be attenuated by a postlimiter filter as per FCC regulations.

7.4.10.10 Audio Distortion

Audio harmonic distortion shall not exceed ___ within 1,000 Hz test tone at a level sufficient to produce ____ deviation, in compliance with EIA Standard RS-152B.

7.4.10.11 Audio Frequency Response

Audio frequency response shall not vary more than +1, -3 dB from a 6 dB per octave preemphasis characteristic from 300 to 3,000 Hz as referenced to the 1,000 Hz level, to comply with EIA Standard RS-152B.

7.4.11 Receiver Characteristics

7.4.11.1 General

The receiver shall employ only solid state circuitry, and be of the single conversion superheterodyne type, with one crystal controlled oscillator and one mixer.

Major selectivity elements shall precede the major gain determining elements to minimize effects from signals on other channels. The major portion of the receiver rejection capabilities shall be controlled by filters in the IF section which collectively exhibit a sharp-skirted bandpass characteristic.

7.4.11.2 Quieting Sensitivity

An "on channel" signal of ____ microvolts or less, when impressed across the antenna output, shall produce ___ dB of noise quieting in accordance with EIA Standard RS-204.

7.4.11.3 Usable (EIA-SINAD) Sensitivity

Usable sensitivity shall be at least ____ microvolts for a ___ dB ratio of signal-plus-noise-plus-distortion to noise-plus-distortion, to comply with EIA Standard RS-204.

7.4.11.4 Selectivity

Selectivity characteristics shall be at least ____ dB at + 25 KHz when measured in accordance with EIA Standard RS-204.

7.4.11.5 Intermodulation Spurious Attenuation

The intermodulation spurious response attenuation at the usable sensitivity level shall be at least ____ dB when measured as prescribed in EIA Standard RS-204.

7.4.11.6 Spurious Response Attenuation

Spurious responses should be attenuated at least ____ dB below the on-frequency signal level which produces ____ dB of noise quieting in compliance with EIA Standard RS-204.

7.4.11.7 Modulation Acceptance

The modulation acceptance bandwidth of the receiver should be a minimum of + 7 KHz when measured in accordance with EIA Standard RS-204.

7.4.11.8 Audio Frequency Response

Audio frequency response shall be within ____, -____ dB of the nornal 6 dB per octave deemphasis characteristic from 300 to 3,000 Hz, measured in accordance with EIA Standard RS-204.

7.4.11.9 Control Unit

The control head shall be of a compact, rugged, and safety-oriented design. All controls required for operation of the radio set shall be included as part of the equipment. The unit shall be constructed of molded high impact plastic material, to provide a chip-free and scratch-resistant surface of maximum durability.

The control unit shall be operable in temperatures ranging from ____°C to ____°C and have current drain not to exceed ___ ma at ____ volts.

All interconnections to the control units shall be accomplished by plug-in connectors.

7.4.11.10 Microphone

A palm-type microphone with a built-in transistorized preamplifier shall be supplied with the radio set. A push-to-talk switch shall be mounted on the microphone housing in such a way as to be easy to use. The microphone cable shall

be of the self-retracting, coil cord type.

7.4.11.11 Control Cabling

All cabling required to interconnect the radio set control unit, vehicle battery and fusing facilities shall be included. All such cables shall be of insulated, weather-proof material.

All wiring except the antenna cable shall enter the radio set at a single connector located on the front of the radio unit. The connector shall be held firmly in place to prevent loosening from vibration, shock or other adverse conditions of mobile radio operation. The connector shall be quick-disconnect for installation convenience with no screw fasteners incroporated in its design.

8.0 ANTENNA SYSTEM

Specific coverage patterns, gain, and other characteristics of base, fixed, or mobile antennas will be determined during the design and procurement phases of system implementation.

For the purposes of standardization and the setting of minimum requirements EIA Standards RS-329 Parts I and II as included herein, may be used in the formulation of Mobile Radio System specifications.

These and other relevant standards are available through the Electronic Industries Association whose address is included at the end of this section.

AMERICAN NATIONAL STANDARD

ANSI/EIA RS-329-A-78
Approved July 17, 1978

EIA STANDARD

Minimum Standards for Land-Mobile Communication Antennas Part I - Base or Fixed Station Antennas

RS-329-A
(Revision of RS-329)

DECEMBER 1975

Engineering Department

ELECTRONIC INDUSTRIES ASSOCIATION

NOTICE

EIA engineering standards are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such standards shall not in any respect preclude any member or non-member of EIA from manufacturing or selling products not conforming to such standards.

Recommended standards are adopted by EIA without regard to whether or not their adoption may involve patents on articles, materials, or processes. By such action, EIA does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the recommended standards.

Published by

ELECTRONIC INDUSTRIES ASSOCIATION

Engineering Department

2001 Eye Street, N. W., Washington, D. C. 20006

Price $3.00

Printed in U.S.A.

MINIMUM STANDARDS FOR LAND–MOBILE COMMUNICATION ANTENNAS

PART I – BASE OR FIXED STATION ANTENNAS

(From Standards Proposal No. 905 and SP-1184 formulated under the cognizance of EIA Subcommittee TR-8.11 on Antennas.)

1. INTRODUCTION

1.1 Scope

This standard details the minimum performance requirements for base or fixed station passive antennas for use from 25 MHz to 1 GHz. Test conditions and methods for measuring the characteristics of these antennas are given for establishing conformance to these requirements. Site variations including ground reflections are not considered.

1.2 Definition

Base or fixed station antennas are antennas used for the Land–Mobile Communications service at the base station or fixed station in a radio relay link.

2. ELECTRICAL STANDARDS

2.1 Standard References and Test Conditions

Standard references and test conditions are those which shall apply to an antennas while it is being tested for minimum performance requirements. These conditions apply unless otherwise specified.

2.1.1 Standard Impedance

The characteristic impedance of the transmission line connecting test equipment to the antenna under test shall be 50 ohms ± 5%.

2.1.2 Half–Wave Dipole

A half-wave dipole is an antenna formed by a straight metallic radiator, one–half wavelength long, whose diameter is small compared to its length, so energized that the current has two nodes, one at each end, producing a maximum radiation in the plane normal to its axis (IEEE).

2.1.3 Standard Gain Unit

The gain of a lossless half–wave dipole shall be used as the standard gain unit. The power gain of an antenna (see 2.11) shall be expressed in db over that of a lossless half–wave dipole, or dBd.

The gain of a lossless half–wave dipole in the plane perpendicular to its axis is therefore xero dBd.

2.1.4 Standard Antenna

The configuration of the standard antenna is shown in Figure 1. It consists of two parallel half-wave dipoles connected in parallel by two symmetrical sections of balanced open wire line as shown. The dipoles are one–half wavelength apart, and are located one-quarter wavelength away from a conducting ground screen one wavelength by one wavelength in size. There shall be one standard antenna for each of the bands noted. Table 1 below gives the dimension for each antenna. NOTE: Standard antenna dimensions defined in the predecessor standard are valid and may be used for their specified frequency bands.

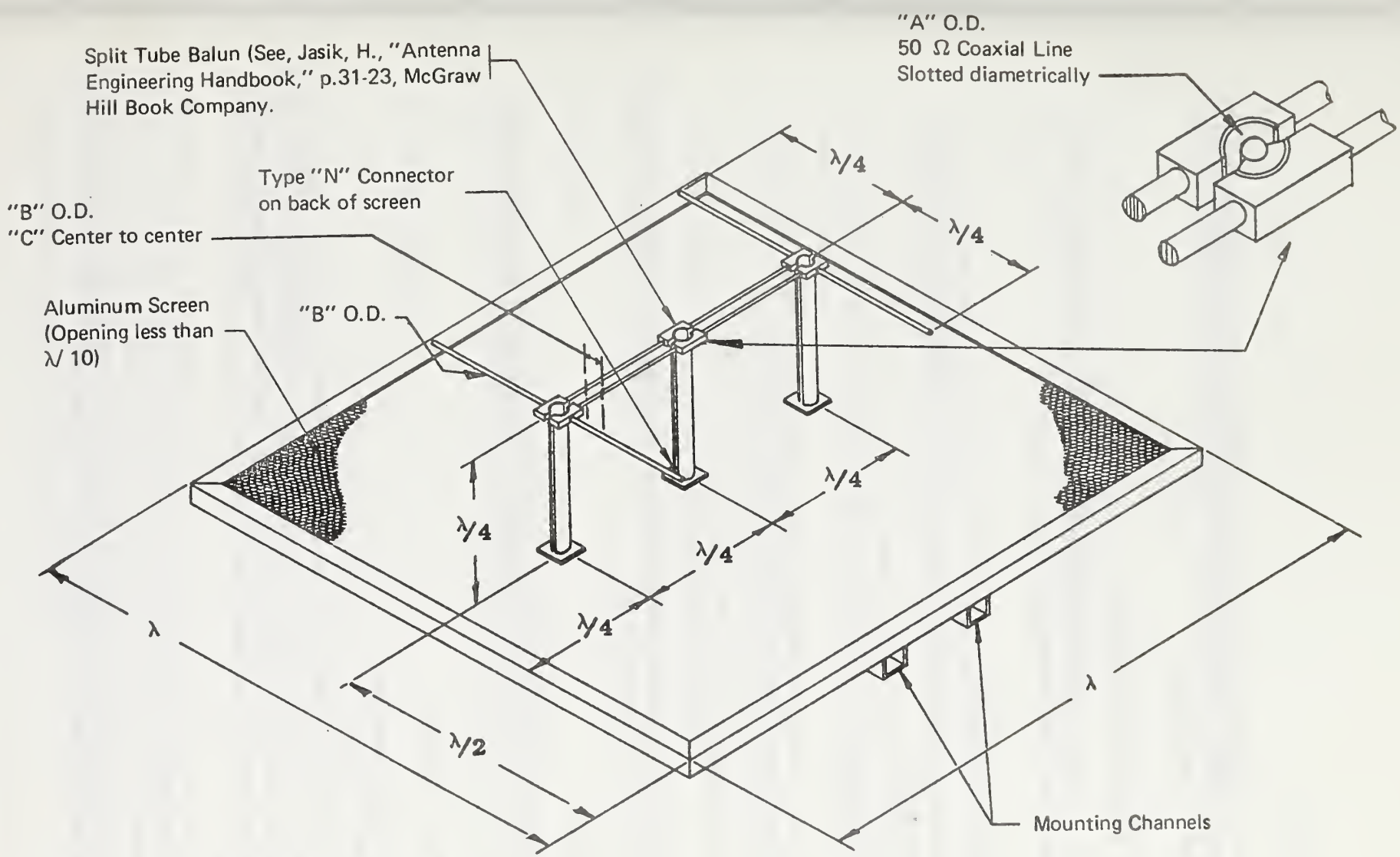
The gains of these standard antennas, as determined by measurements made by the National Bureau of Standards, are given in Table 2.

TABLE 1

BAND	λ	A	B	C
148–194 MHz	1875. mm (73.8 in)	41.1 mm (1.62 in)	17.45 mm (0.687 in)	38.38 mm (1.511 in)
406–450 MHz	701. mm (27.6 in)	22.1 mm (0.87 in)	7.92 mm (0.312 in)	17.45 mm (0.687 in)
450–512 MHz	622. mm (24.5 in)	22.1 mm (0.87 in)	7.92 mm (0.312 in)	17.45 mm (0.687 in)
800–960 MHz	343. mm (13.5 in)	7.9 mm (0.31 in)	4.75 mm (0.187 in)	10.44 mm (0.411 in)

TABLE 2

BAND, MHz	Freq. MHz	Gain, dBd	Band, MHz	Freq. MHz	Gain, dBd
148–174	148	7.5	450–512	450	7.5
	160	7.7		481	7.7
	174	8.0		512	7.9
406–450	406	7.6	800–960	800	7.5
	428	7.7		882	7.7
	450	7.9		960	8.0



NOTE: λ is the wavelength of the center frequency of a given band, namely, 160 MHz, 428 MHz, 481 MHz and 882 MHz. For dimensions of A, B, and C see Table 1.

FIGURE 1 – GAIN STANDARD ANTENNA

2.1.5 Test Site

The test site is the general vicinity of the antenna under test. Specific conditions for the test site are stated in detail in section 2.3.3 for VSWR test and in sections 2.4.3 and 2.11.3 for pattern and gain measurements.

2.1.5.1 Effective antenna Volume

The effective antenna volume is the actual volume occupied by the radiating part of the antenna plus one–half wavelength all the way around.

2.1.5.2 Source Antenna

The source antenna is any antenna that illuminates the antenna under test for gain or radiation pattern.

2.1.5.3 Test Range

The test range is the space enclosing the source antenna and the antenna under test. Conditions for the test range are stated in detail in section 2.4.3.1.

2.1.6 Ambient Conditions

Measurements of VSWR, radiation pattern and antenna power gain may be made at outdoor test sites under prevailing weather conditions.

2.1.7 Polarization

The polarization of an antenna is the orientation of the electric vector of the wave radiated by the antenna.

2.2 Special Test and Conditions

2.2.1 Scale Model Measurements

Methods for the antenna radiation pattern and gain measurements are stated in sections 2.4.3 and 2.11.3. However, at frequencies below 132 MHz, meaningful and accurate results of these measurements are difficult to obtain on a full-size antenna. In this case, scale model techniques shall be used. It shall be stated in the published literature that the results are obtained by scale model measurements.

2.2.1.1 Scale Ratio

The scale ratio is the ratio of the operating frequency of the scale model to that of the full-size antenna. The ratio shall not exceed 6.

2.2.1.2 Linear Accuracy

The scale model shall be constructed to the following accuracy or better:

$$L_s = (L \pm 1\%)/R$$

where R is the scale ratio, L_s is any significant linear dimension of the scale model, and L is the corresponding linear dimension of the full-size antenna.

2.2.1.3

Parts of the scale model shall be constructed of the same material as the corresponding parts of the full-size antenna.

NOTE: Although this is not in strict conformance with scale model techniques, the errors introduced are thought to be small enough that the accuracy of measurement will not be noticeably impaired.

2.2.1.4

If the supporting tower and mast are electrically essential parts of the antenna, or affect the electrical performance of the antenna, they shall be scaled also.

2.3 Voltage Standing Wave Ratio (VSWR)

2.3.1 Definition

Voltage standing wave ratio (VSWR) of the antenna is the ratio of the maximum to the minimum values of voltage in the standing wave pattern that appears along a lossless 50-ohm line with the antenna as load.

2.3.2 Minimum Standard

The VSWR shall not exceed 1.5 at the specified frequency or over the specified band of frequencies.

2.3.3 Method of Measurement

2.3.3.1 Test Procedure

The antenna shall be connected to an RF signal source through a VSWR measuring device, such as a slotted line, bridge or other device, that has a nominal impedance of 50 ohms and a residual VSWR of not more than 1.05. The VSWR, as read on the slotted line or other measuring device, will be the VSWR of the antenna at the selected frequency. If the RF loss in the line connecting the antenna to the VSWR measuring device exceeds ½ dB, the measured VSWR values shall be properly corrected to eliminate the effects of the line loss.

2.3.3.2 Test Site

The antenna under test shall be located in a space relatively free from reflections and sufficiently far from test equipment and personnel. The test site is considered to be satisfactory if the change in VSWR reading is less than 0.1 when the antenna is moved around and up-and-down by plus or minus one-quarter of a wavelength.

2.3.3.3 Effect of Supporting Structure

For certain applications such as side-mounted vertical radiators, the supporting structure is in the RF field of the antenna. In this case, the antenna supporting structure shall be included in the mounting of the antenna under the VSWR test.

2.4 Radiation Pattern

2.4.1 Definition

The radiation pattern is a graphical representation of the magnitude of the relative electric field strength radiated from an antenna in a given plane plotted against direction from a given reference.

2.4.2 Standard

The radiation pattern, when given, shall be for either the horizontal plane or the vertical plane. The polarization shall be specified.

2.4.3 Method of Measurement

Owing to the principle of reciprocity, test results obtained with the source antenna transmitting and the antenna under test receiving, are the same as those obtained with the source antenna receiving and the antenna under test transmitting. For brevity, the following sections assume that the source antenna is a transmitting antenna.

2.4.3.1 Test Range

A typical test set-up for radiation pattern measurement is shown in Figure 2. There are three types described as follows:

1. Ground Level Range—A ground level range is a range where both antennas are close to the ground. The source and test antenna heights, h_s and h_g in Figure 2, are adjusted to place the first maximum of the interference pattern, of the source antenna and its image, at the center of the test aperture.

2. Elevated Range—An elevated range is a range where both test and source antennas are elevated sufficiently to place a minimum of the source antenna at the reflection point,

while simultaneously aligning the major lobe maxima of both antennas. The two heights h_a and h_s in Figure 2, are generally equal.

3. Slant Range—A slant range is a range where the source antenna is placed near the ground, and the test antenna is placed at the single elevated point. The angle $\propto$ in Figure 2 is on the order of tens of degrees.

2.4.3.2 Test Procedure

A signal source tuned to the test frequency is connected to a source antenna. The radiated signal is received on the antenna under test. The latter is so mounted that it is similarly polarized to the source antenna. The antenna under test is connected to a radio received calibrated to measure the signal level at its input. The antenna under test is rotated around an axis perpendicular to the line between its center and the center of the source antenna, as shown in Figure 2, and the received signal is recorded continuously through 360° of rotation.

1. Horizontal Pattern—For horizontal pattern test, the vertical direction of the antenna in its normal operating position shall be the axis of rotation in the test.

2. Vertical Pattern—For vertical pattern test, the vertical direction of the antenna in its normal operating position shall be perpendicular to the axis of rotation in the test.

2.4.3.3 Test Conditions

1. The separation between the source antenna and the antenna under test shall be at least ten wavelengths, or twice the square of the maximum dimension of the antenna divided by wavelength, whichever is greater.

2. The radio receiver used as the signal detector shall present an impedance of 50 ohms (1.5:1 VSWR or less) to the antenna under test, for all frequencies used for the measurements.

3. Both the signal output of the signal source and the sensitivity of receiving equipment shall be monitored so as to insure that they are maintained constant during the test.

4. The antenna under test shall be placed in an area where the field is substantially uniform. The field shall be probed by a half-wave dipole over the effective antenna volume (see 2.1.5.1) of the antenna under test. If the field intensity variation is greater than ± ¾ dB, the test site shall be considered unusable.

2.5 Omni-Directional Antenna

2.5.1 Definition

An omni-directional antenna is an antenna having an essentially non-directive pattern in azimuth and a directive pattern in elevation (ANSI Standard).

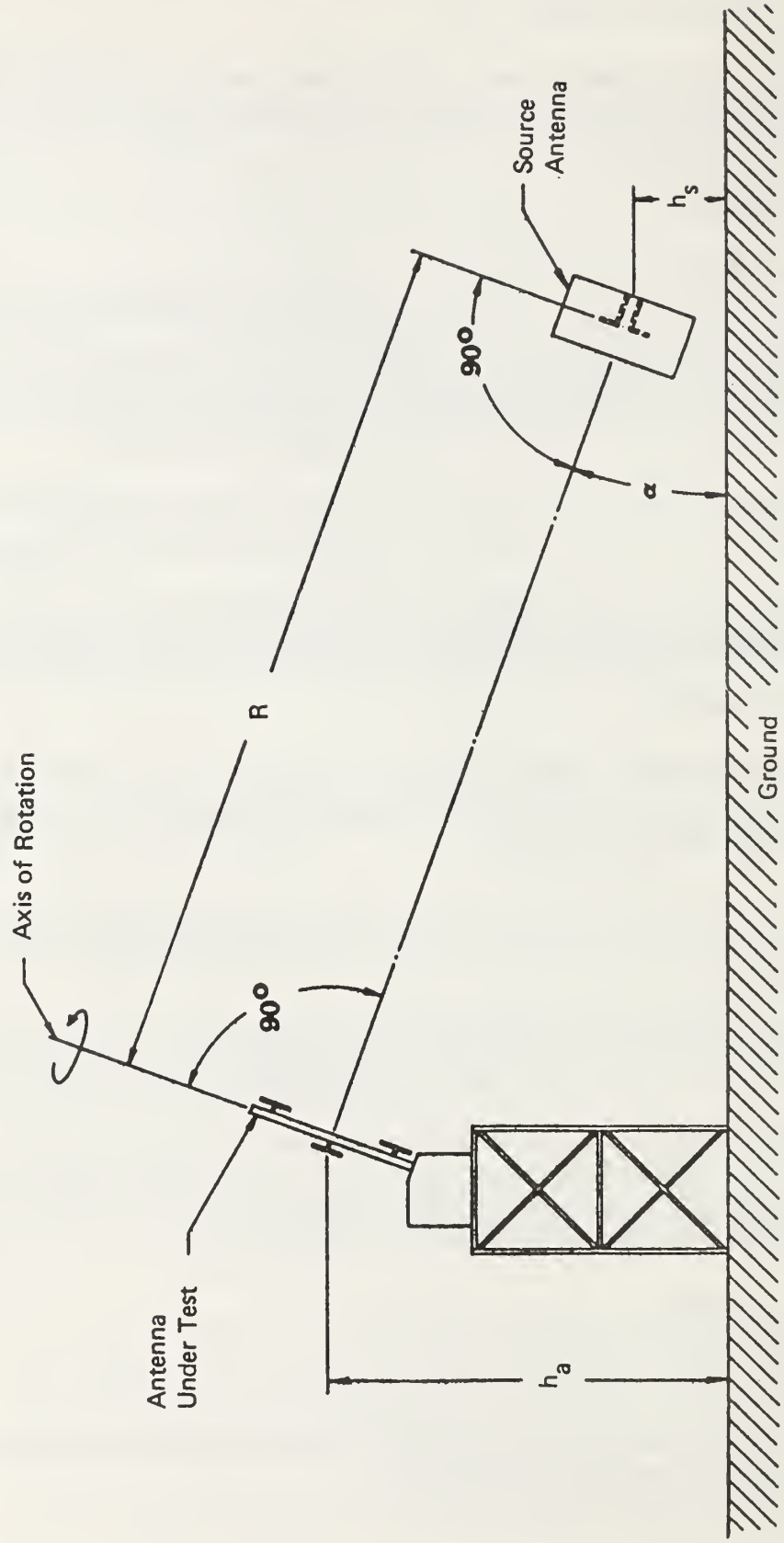


FIGURE 2 – TEST RANGE

2.5.2 Minimum Standard

The relative gain of an omni-directional antenna in any azimuth direction shall not vary from the mean value by more than ± 1½ dB for 360° of rotation.

2.5.3 Method of Measurement

Same as that for the Radiation Pattern Test (2.4.3).

2.6 Pattern Circularity

2.6.1 Definition

The pattern circularity of an omni-directional antenna is the deviation of its horizontal radiation pattern from a true circle.

2.6.2 Standard

The departure from circularity measured from a mean value shall be stated in plus and minus dB by the manufacturer.

2.6.3 Method of Measurement

Same as that for Radiation Pattern Test (2.4.3).

2.7 Directional Antenna

2.7.1 Definition

A directional antenna is an antenna which radiates or receives radio waves more effectively in some azimuthal directions than in others.

2.7.1.1 Radiation Lobe

Radiation lobe is a portion of a radiation pattern bounded by one or two angular regions of minimum radiated electric field.

2.7.1.2 Major Lobe

The radiation lobe containing the direction of maximum radiation.

2.7.1.3 Minor Lobe

Any radiation lobe except the major lobe.

2.7.2 Standard

A directional antenna shall have one or more major lobes in the horizontal pattern whose maximum relative gain shall exceed the minimum relative gain by more than 3 dB.

The manufacturer shall show all the lobes down to 20 dB below the major lobe on the radiation pattern.

2.7.3 Method of Measurement

Same as that for Radiation Pattern Test (see 2.4.3).

2.8 Horizontal Beamwidth

2.8.1 Definition

The Horizontal Beamwidth of an antenna is the angular width including maximum radiation measured between the two points on the major lobe of the horizontal pattern 3 dB below the maximum.

2.8.2 Standard

The Horizontal Beamwidth shall be stated by the manufacturer.

2.8.3 Method of Measurement

Same as that for the Radiation Pattern Test (2.4.3).

2.9 Vertical Beamwidth

2.9.1 Definition

The Vertical Beamwidth of an antenna is the angular width including maximum radiation measured between the two points on the major lobe of the vertical pattern 3 dB below the maximum.

2.9.2 Standard

The Vertical Beamwidth shall be stated by the manufacturer.

2.9.3 Method of Measurement

Same as that for the Radiation Pattern Test (see 2.4.3).

2.10 Elevation Beam Tilt

2.10.1 Definition

Elevation Beam Tilt of an antenna is the angle between the direction of maximum radiation and the horizontal plane.

2.10.2 Standard

Elevation Beam Tilt and gain in the horizontal plane shall be stated by the antenna manufacturer or indicated in the published vertical radiation pattern.

2.10.3 Method of Measurement

Same as that for the Radiation Pattern Test (see 2.4.3).

2.11 Antenna Power Gain

2.11.1 Definition

The power gain of an antenna is the ratio of its maximum radiation intensity in a stated direction to the maximum radiation intensity of a lossless reference antenna with identical input power.

2.11.2 Standard

The power gain of the antenna shall be expressed in dB over the gain of a lossless half-wave dipole, or dBd. The power gain shall be stated by the manufacturer. The measured power gain shall not be less than that stated by the manufacturer at any stated frequency or band of frequencies.

2.11.3 Method of Measurement

2.11.3.1 Test Range

Same as that for pattern test (see 2.4.3.1) as shown in Figure 2.

2.11.3.2 Test Procedure

Substitution Method shall be used for measuring the antenna power gain.

1. A signal source tuned to the test frequency is connected to a source antenna. The radiated signal is received on the antenna under test. The latter is so mounted that it is similarly polarized to the source antenna. The antenna under test is connected to a radio receiver calibrated to measure the signal level at its input. The antenna

under test is rotated and adjusted until the receiver signal power level reaches the maximum. This level is designated as P_a.

2. The antenna under test is removed and the standard antenna, with gain G_s as listed in section 2.1.4, is substituted in its place. The standard antenna is then rotated and adjusted until the receiver signal power level reaches the maximum. This level is designated as P_s.

3. The measured power gain of the antenna in the direction of its maximum radiation is:

$$G_a = 10 \log (P_a/P_s) + G_s \text{ dBd}$$

It is noted that measured gain referred to the maximum direction has the advantage that the reading, P_a, obtained in step 1, is steady and insensitive to small antenna movement or vibration, and that measurement accuracy is improved. However, two corrections shall be made according to steps 4 and 5 whenever they are applicable.

4. Beamtilt Correction—If the intended direction of radiation from the antenna differs from the direction of maximum radiation due to beamtilt (2.10.1), then the measured gain, G_a shall be corrected to give:

$$G_b = G_a - L_b \text{ dBd}$$

where L_b is the loss due to beamtilt. The value of L_b can be obtained from the vertical radiation pattern of the antenna.

Note: Beamtilt correction may be eliminated if, when the antenna under test is mounted and adjusted as described in paragraph (1) above, its radiation on its normal horizon is directed towards the source antenna.

5. Circularity Correction—If the antenna is intended for omni-directional coverage in the horizontal plane, measured gain shall be further corrected to give:

$$G_o = G_b - L_o \text{ dBd}$$

where G_b is obtained in step 4 and L_o is the power level difference in dB between the azimuthal average value and the value from which G_b is obtained. G_o is then the average antenna power gain in dBd in azimuth.

6. The antenna power gain shall be measured for frequencies (at least three) sufficient to define the variation over the specified frequency band.

2.11.3.3 Test Conditions

Test conditions for Radiation Patttern Test (see 2.4.3.3) shall be observed. The measurements shall be made by changing the antenna position in increments of one-tenth wavelength

along the axis of rotation or, alternately, in the direction of propagation (shown in Figure 2). The mean result of ten measurements shall be used.

2.12 Antenna Power Rating

2.12.1 Definition

Antenna power rating is the maximum CW power which can be continuously applied to the antenna without degrading its performance.

2.12.2 Standard

The maximum power rating shall be stated by the antenna manufacturer. Unless otherwise specified, an ambient temperature of 60°C (140°F) shall be assumed.

2.12.3 Method of Determination

Stated power rating may be determined analytically or by actual test. The actual test method shall consist of the application of specified power (CW) to the antenna for a continuous period of 4 hours.

2.13 Bandwidth

2.13.1 Definition

The INSTANTANEOUS bandwidth of the antenna is the frequency range or ranges over which it will perform within specifications without changing tuning adjustments.

The TUNEABLE bandwidth of the antenna is the frequency range or ranges over which the INSTANTANEOUS bandwidth may be adjusted.

3. STRUCTURAL STANDARDS

3.1 Factor of Safety

3.1.1 Definition

The factor of safety of a member under stress is the number which results by dividing the yield point of the material by the actual unit stress on the section area.

3.1.2 Standard

The factor of safety for antenna assemblies shall not be less than 1.65 based on the yield point of the material.

3.1.3 Method of Determination

The factor of safety shall be determined by dividing the yield stress of the material by the maximum working stress of the material. The maximum working stress shall be measured or calculated.

3.2 Wind Loads

3.2.1 Definition

Wind loading on an antenna assembly shall be those moments and forces caused by the specified wind pressure acting in the direction which produces the maximum value of those forces and moments.

3.2.2 Standard

Antenna assemblies when fully loaded shall be designed for a wind pressure of not less than 30 pounds per square foot on flat surfaces, without ice coatings. The manufacturer of antenna assemblies shall furnish the maximum calculated forces and moments at points of attachment upon the request of the user. Calculations shall consider a temperature range of -40^{o}C to $+60^{o}$C (-40^{o}F to $+140^{o}$F).

3.2.3 Method of Determination

Maximum forces due to wind load on the assembly shall be calculated. If the area includes several members of different shapes, appropriate shape factors shall be used. The shape factor for round surfaces is 2/3 of that of flat surfaces. Maximum torque due to wind load shall be calculated assuming that the direction of the wind pressure is that which produces maximum torque on the antenna support.

Note: Wind pressure is proportional to the square of the actual wind velocity. Expressed as a formula, $P = KV^2$, where P is the wind pressure in Pascals (pounds/ft^2), K is the wind conversion factor assumed to be 0.96 (0.004), and V is the actual wind velocity at the antenna in $\frac{\text{meters}}{\text{/sec}}$ (mi/hr).

3.3 Galvanic Corrosion

3.3.1 Definition

Galvanic corrosion is the acceleration of corrosive action due to dissimilar metals in contact in the presence of moisture. The action is that of a galvanic cell, in which the metals act as electrodes, with the metal that is corroded acting as an anode with respect to the other metal.

3.3.2 Standard

Good engineering practice shall be followed in design, using compatible materials. The qualitative tables in the latest MIL-E-16400 may be used as a guide.

3.4 Resistance to Weathering, Fatigue, and Cold Flow

3.4.1 Definition

Resistance to weather, fatigue, and cold flow is the ability to operate in exposed positions over prolonged periods of time without appreciable degradation of structural strength or electrical characteristics due to corrosion or other chemical decomposition, or fatigue, or cold flow.

3.4.2 Standard

The composition of materials and finishes used shall be a characteristic of the antenna model (or type) which is claimed by the manufacturer to meet this standard. These compositions shall be available from the manufacturer and shall not be changed without changing model (or type) number unless such changes do not degrade resistance to weathering fatigue or cold flow.


ΕΙΑ

EIA STANDARD

Minimum Standards for Land - Mobile Communication Antennas
Part II — Vehicular Antennas

RS-329-1

(Addition to RS - 329)

August 1972

Engineering Department

ELECTRONIC INDUSTRIES ASSOCIATION

NOTICE

EIA engineering standards are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such standards shall not in any respect preclude any member or non-member of EIA from manufacturing or selling products not conforming to such standards, nor shall the existence of such standards preclude their voluntary use by those other than EIA members whether the standard is to be used either domestically or internationally.

Recommended standards are adopted by EIA without regard to whether or not their adoption may involve patents on articles, materials, or processes. By such action, EIA does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the recommended standards.

Published by

ELECTRONIC INDUSTRIES ASSOCIATION

Engineering Department

2001 Eye Street, N. W., Washington, D. C. 20006

PRICE: $2.20

Printed in U.S.A.

MINIMUM STANDARD FOR COMMUNICATION ANTENNAS
PART II – VEHICULAR ANTENNAS

(From Standards Proposal No. 1106, formulated under the cognizance of EIA Subcommittee TR-8.11 on Land - Mobile Services.)

4 INTRODUCTION

4.1 Scope –

This standard details the minimum performance requirements for mobile antennas as defined in paragraph 4.2 below. Only passive antennas for use from 132 - 1000 MHz are covered. Test conditions and methods for measuring the characteristics of these antennas are given for establishing conformance to these requirements.

4.2 Definition –

Mobile antennas are antennas mounted on vehicles and used for the Land - Mobile Communications service.

5 ELECTRICAL STANDARDS

5.1 Standard References and Test Conditions –

Standard references and test conditions are those which shall apply to an antenna while it is being tested for minimum performance requirements. These conditions apply unless otherwise specified.

5.1.1 Standard Impedance –
The characteristic impedance of the transmission line connecting test equipment to the test antenna shall be 50 ohms ± 5%. The nominal impedance of the antenna and all test equipment shall be 50 ohms.

5.1.2 Bandwidth –
The bandwidth of the antenna is the frequency range over which the antenna shall perform within all the stated electrical performance specifications.

5.1.3 Polarization –
The polarization of an antenna is the orientation of the electric vector of the wave radiated by the antenna. For this standard, the antennas shall always be vertically polarized.

5.1.4 Test Vehicle –
For antennas intended for passenger car use, the test vehicle shall be a late model 4 - door full - size sedan of American make. Late model shall mean no more than 4 years old at the time of test. An earlier model may be used if the physical dimensions fall within the range of the cars as specified above.

The test antenna shall be mounted in the location in which it will be used. If intended for roof mounting, the antenna shall be mounted in the physical center (± 2 inches) of the roof of the test vehicle.

5.1.5 Mobile Standard Antenna –

The Mobile Standard Antenna shall be a matched, lossless quarter-wavelength whip mounted in the center ($\pm$ 2 inches) of the roof of the test vehicle. Matched shall mean no greater than 1.5:1 VSWR. The whip material shall have a resistivity no greater than 6.0×10^{-6} ohm – cm or be plated with such a metal. The diameter of the whip shall be no less than 3/64". Other components may be of any material, but the total loss of the mount shall be no more than 0.1 dB. The total height above the mounting surface shall be that of a resonant quarter-wavelength $\pm$ 10% at the test frequency.

5.1.6 Test Site –

The test site is the general vicinity of the test antenna and test vehicle. Specified conditions are stated in detail in Sections 5.2.3.2, 5.3.3.2, and 5.5.4.

5.1.6.1 Source Antenna –

The source antenna is any antenna that can properly illuminate the effective antenna volume of the test antenna. It shall be mounted so that the line from its center of radiation to the roof of the test vehicle is no more than 1^{o} from horizontal. The minimum spacing between the test antenna and source antenna shall be $2D^2/\lambda$ where D is the maximum dimension of the vehicle, or 10 wavelengths, whichever is greater.

5.1.6.2 Effective Antenna Volume –

The effective antenna volume is the actual volume occupied by the antenna and vehicle plus $\lambda/2$ in all directions.

5.1.6.3 Ambient Conditions –

Measurements may be made at outdoor test sites under prevailing weather conditions. See 5.5.4.4 for power testing exceptions.

5.2 Voltage Standing Wave Ratio (VSWR)

5.2.1 Definition –

Voltage standing wave ratio of the antenna is the ratio of the maximum to the minimum values of voltage in the standing wave pattern that appears along a lossless 50 ohm line with the antenna as a load.

5.2.2 Minimum Standard –

The maximum VSWR shall be stated. This shall be the maximum VSWR occurring over the specified band of frequencies.

5.2.3 Method of Measurement

5.2.3.1 Test Procedure –

The antenna shall be connected to an RF signal source through a VSWR measuring device, such as a slotted line, bridge or other device that has a residual VSWR of not more than 1.05:1. The VSWR will be measured across the entire specified frequency band. If the RF loss in the line connecting the antenna to the measuring device exceeds 0.5 dB, the measured VSWR values shall be corrected to eliminate the effects of line loss.

5.2.3.2 Test Conditions –
The test vehicle shall be located in a space relatively free from reflection and sufficiently far from test equipment and personnel (unless inside vehicle). The test site is considered satisfactory if the change in VSWR reading is less than 0.1 when the vehicle is moved back and forth one car length.

5.3 Radiation Pattern

5.3.1 Definition –
The radiation pattern is a graphical representation of the relative field strength radiated from an antenna in a given plane plotted against the angular distance from a given reference direction. The front of the vehicle shall be designated as 0^{o}.

5.3.2 Standard –
The radiation pattern shall be measured in the horizontal plane within the limits specified in 5.1.6.1.

5.3.3 Method of Measurement –
The following sections assume that the source antenna is a transmitting antenna, and the test antenna is a receiving antenna. It will be understood that, due to reciprocity, the modes may be switched with the same results.

5.3.3.1 Test Procedure –
A signal source tuned to the test frequency is connected to the source antenna. The test antenna is connected to a calibrated receiver. The test vehicle is rotated around its physical center through 360^{o} while the received signal is monitored and recorded.

The test vehicle may be rotated with either of two methods: the vehicle may be mounted on a ground level turntable which is rotated during pattern taking, or the vehicle may be positioned along radial lines, $22\frac{1}{2}^{o}$ apart. The angle must be recorded along with the signal level.

The same procedure must be followed for the test antenna and the Mobile Standard Antenna for the purposes of measuring power gain (see 5.4).

5.3.3.2 Test Conditions

5.3.3.2.1 The vehicle shall be located in a space relatively free from reflection and sufficiently far from test equipment and personnel (unless located inside the vehicle). The field shall be probed by mounting a Mobile Standard Antenna and moving the vehicle $\pm \lambda/2$ along the line connecting the source and test antennas. The same probing shall be made along a line perpendicular to this line. If the variation is greater than $\pm$ 3/4 dB, the test site shall be considered unusable.

5.3.3.2.2 The 0^{o} reading shall be taken at the start and end of each pattern run. If the two readings differ by more than 0.5 dB, the run is void and must be retaken. This is primarily intended for those cases where a turntable is not used, and is a check on the positioning accuracy.

5.3.3.2.3 The type and length of cable connecting the test antenna to the receiver shall be the same as for the Mobile Standard Antenna so that there is no difference in cable losses.

5.3.3.2.4 The output of the signal source shall be monitored to insure that it remains constant during the test. The combined stability of all test equipment must be maintained within $\pm$ 0.1 dB.

5.3.3.2.5 All controllable conditions shall be the same when running the test antenna and the Mobile Standard Antenna. The Mobile Standard Antenna run shall be made immediately following the test antenna run so that any changes in propagation characteristics are kept to a minimum.

5.4 Antenna Power Gain

5.4.1 Definition –

The power gain of an antenna is the ratio of the average radiation intensity of the test antenna to the average radiation intensity of the Mobile Standard Antenna with all other conditions remaining equal. The average radiation intensity is the average over 360° in the horizontal plane.

5.4.2 Standard –

The power gain of the antenna shall be expressed in dB with respect to the Mobile Standard Antenna. The power gain shall be stated by the manufacturer. If the antenna is to be used over a range of frequencies, the stated gain shall be the minimum gain over that range.

5.4.3 Method of Calculation –

The power gain is calculated from the horizontal patterns from 5.3. The average signal power level for each pattern is found by finding the signal at 22½° intervals (16 points) and calculating the arithmetic mean of these points. Let Pa be the average signal power level for the Mobile Standard Antenna. The power gain is then:

$$Ga = 10 \log \frac{Pa}{Ps}$$

The gain shall be measured for frequencies at both ends and center of the specified frequency band.

5.5 Antenna Power Rating

5.5.1 Definition –

Antenna Power Rating is the maximum CW power which can be applied to the antenna without degrading its performance such that the stated specifications are not met.

5.5.2 Standard –

The antenna manufacturer shall state the Intermittent Power Rating and/or the Continuous Power Rating.

5.5.3 Method of Determination –

5.5.3.1 Intermittent –
The antenna shall be subjected to 1 minute transmit and 4 minutes off at rated power for 4 hours. After completion of the 4 hour period, there shall be 3 cycles of 5 minutes transmit and 15 minutes off at rated power.

5.5.3.2 Continuous –
The antenna shall be subjected to 4 hours continous transmit at rated power.

5.5.4 Test Conditions

5.5.4.1 A transmitter of suggiciently high power rating shall be used for the test. If there is any power slump, the transmitter must be adjusted so that the power does not fall below the test level for the duration of the test.

5.5.4.2 The power level shall be measured at the antenna terminals. If the RF loss in the line connecting the antenna to the wattmeter exceeds 0.5 dB, the measured power shall be corrected to eliminate the effects of line loss.

5.5.4.3 The test shall be performed in a space relatively free from reflections.

5.5.4.4 The ambient terperature must be between 20° C and 30° C.

6 MECHANICAL STANDARDS

6.1 Shock Stability

6.1.1 Definition –

Shock stability is the ability of the antenna to maintain specified performance after being shocked.

6.1.2 Minimum Standard –

The antenna shall be able to withstand 1500 blows with a 2 inch diameter metal rod at a height equivalent to 12 inches above the roof of the test vehicle. The force of the blows shall be equivalent to the vehicle moving at 10 MPH. No degradation in electrical performance shall occur.

6.1.3 Method of Determination –

The antenna shall be mounted on a stationary supporting structure. The metal rod shall be mounted on a movable apparatus driven by a piston or motor capable of moving the rod at 10 MPH at the time it strikes the antenna. If the antenna is intended for roof mount, the height of the blow shall be adjusted to 12" above the mounting surface and the required number of blows shall be administered.

An alternative method is to have the rod stationary and to have the antenna and supporting structure move.

6.2 Vibration Stability

6.2.1 Definition –

Vibration stability is the ability of the equipment to maintain specified performance after being vibrated.

6.2.2 Minimum Standard –

No fixed part shall become loose or movable part shifted in position or adjustment under vibration. After vibration the antenna shall meet all electrical specifications.

6.2.3 Method of Determination –

The antenna shall be vibrated in the plane perpendicular to its axis with simple harmonic motion having an amplitude of 0.030" (total excursion 0.060") while varying the frequency slowly between 10 and 60 Hz.

(a) The frequency at which the antenna has its most severe resonance shall be noted and designated Fo. The antenna shall then be vibrated in the same plane with the same amplitude while varying the frequency uniformly from 0.9 Fo to 1.1 Fo and back to 0.9 Fo. The cycle shall be accomplished in 5 minutes and shall be repeated continually for 4 hours.

(b) If no resonance is found, the antenna shall be vibrated in the same plane with the same amplitude while varying the frequency uniformly from 10 to 60 Hz, and back to 10 Hz. The cycle shall be accomplished in 5 minutes and shall be repeated continually for a period of 8 hours.

6.3 Galvanic Corrosion

6.3.1 Definition –

Galvanic corrosion is the acceleration of corrosive action due to dissimilar metals in contact in the presence of moisture. The action is that of a galvanic cell, in which the metals act as electrodes, with the metal that is corroded acting as an anode with respect to the other metal.

6.3.2 Standard –

The qualitative talbes in the latest M1L-E-16400 is recommended as a guide.

6.4 Resistance to Weathering, Fatique and Cold Flow

6.4.1 Definition –

Resistance to weather, fatigue and cold flow is the ability to operate in exposed positions over prolonged periods of time without appreciable degradation of structural strength or electrical characteristics due to corrosion or other chemical decomposition, or fatigue, or cold flow.

6.4.2 Standard –

The composition of materials and finishes used shall be a characteristic of the antenna model (or type) which is claimed by the manufacturer to meet this standard. These compositions shall be available from the manufacturer and shall not be changed without changing model (or type) number unless such changes do not degrade resistance to weathering, fatigue, or cold flow.

RELATED EIA STANDARDS

In addition to this Standard, the following Standards in the area of land-mobile communications are available:

RS-152-B	Land Mobile Communication, FM or PM Transmitters (25 to 470 mc)	$ 4.30
RS-237	Minimum Standard for Land Mobile Communication Systems Using FM or PM Equipment 25 - 470 MC	$ 4.10
RS-316	Minimum Standards for Portable/Personal Land Mobile Communications FM or PM Equipment 25 - 470 MC	$ 4.40
RS-329	Minimum Standards for Land Mobile Communication Antennas, Part I – Base or Fixed Station Antennas	$ 3.00
RS-374	Land Mobile Selective Signaling Standard	$ 4.30

For a FREE and complete listing of EIA and JEDEC Standards and Engineering Publications write:

EIA Engineering Department
Standards Orders
2001 Eye Street, N.W.
Washington, D.C. 20006


ELECTRONIC INDUSTRIES
ASSOCIATION
EIA

9.0 ALARM AND CONTROL SYSTEM

9.1 The Alarm and Control System shall be used for transmitting alarm or status messages from remote stations to a central station and for commands from the central station to remote station.

The system shall operate over the UHF mobile relay station system being specified. All radio equipment must be FCC type accepted for application.

9.2 Central Control Unit

The control station shall provide control and display functions for up to _____ remote station locations. Each remote to have _____ control and alarm points, expandable to _____.

The central station shall perform the following:

- Operator interface via a control panel
- Message reception
- Message transmission
- Data display (status and alarm)

9.3 Remote Alarm and Control Unit

9.3.1 General

The status reporting and control unit shall be capable of two-way communication with a central station, and shall be capable of reporting up to _____ input conditions. Inputs shall accommodate a dry-contact closure. The position of this dry contact will be maintained during the transmission and the unit shall report the status of this input. The unit shall report all of its information automatically, upon detection of a change of status of any monitored input. A change of status shall initiate a program of redundant transmissions.

9.3.2 Time-Diversity

A time-diversity technique shall be used to ensure reception in conditions of prolonged interference, such as interfering transmissions from remote stations. The technique shall incorporate the retransmission of the station's information.

9.3.3 Channel Monitoring

The status and control remote shall contain a circuit to monitor activity on the communications channel to prevent the unit from transmitting during busy periods. Transmission shall be barred until the channel is clear.

9.3.4 Interrogation Messages

The status and control unit shall respond to interrogation messages from a central station. Upon receipt of an interrogation message addressed to the remote station, a complete transmission of the remote unit's information shall be transmitted.

9.3.5 Acknowledge Messages

The status and control unit shall respond to acknowledge messages from a central station. Upon receipt of an acknowledge message addressed to the remote station, an acknowledge signal shall be given. The acknowledge signal shall halt the station's time diversity retransmission routine. If a second change of status occurs, the retransmission circuitry shall not be reset.

9.4 RF Transceiver Characteristics

9.4.1 General

The status and control unit shall incorporate a solid-state, FM radio transceiver, to operate in the _____ MHz range. The transmitter shall provide a minimum rf output of _____.

Frequency shall be crystal controlled to ± _____% of the assigned carrier frequency, over a temperature range of _____°C to _____°C. This shall be accomplished without the use of heaters to maintain a low current drain.

Spurious transmissions and harmonics shall be more than ___ dB below carrier.

The transceiver shall comply fully with all applicable EIA Standards and FCC Rules and Regulations. It shall be ____ type accepted for intended application.

10.0 SITE BUILDINGS AND FACILITIES

10.1 General

This specification covers the requirements for the buildings to be supplied and erected for the (Name of Cooperative) _____ Communications System.

All buildings supplied shall be of a _____ type, meeting or exceeding the requirements of this specification.

Buildings shall be installed at the sites specified, on firm and stable foundations, incorporate non-porous wall and roof sections, to preclude capillary action, and shall be so designed, and so constructed to provide a minimum useful life period of 20 years, without need for major maintenance actions. Offerors shall indicate building warranties and/or guarantees in their proposal response.

All buildings furnished shall be of the same size, configuration, and construction.

10.2 Specific Conditions

The buildings to be furnished under this specification shall be designed for the following conditions, and shall not be subject to damage under any individual or combination of conditions.

- ° Winds to _____ MPH
- ° Ambient temperature of ___° to ___°C
- ° Ambient humidity from 0 to _____ percent

10.3 Construction

Under the service conditions listed in 10.2 above, all buildings furnished shall be:

10.3.1 Provided with a smooth, water, air and dust tight homogeneous non-combustible external surface that will not clip, or delaminate under impact of hail or blowing rock during extreme weather conditions. The outside surface shall not contain any unfused joints or penetrations except at doors, air intake or exhaust openings, power service entrance and waveguide ports, and these openings shall be water-tight to the degree that hurricane force winds will not drive moisture around frames or through seals. If fiberglass construction is used, the outside surfaces shall be covered with a gel coating that will prevent undue weather cracking and surface deterioration.

10.3.2 Constructed in such a manner that the total heat transfer through walls, roof, floor and doors will provide a maximum heat transfer factor of _____ BTU/hr/m^2°C temperature difference.

10.3.3 Erected on a concrete foundation, with a concrete floor, and when set in place, satisfy the service conditions herein specified.

10.3.4 Provided with a finished floor of vinyl asbestos (or other comparable finish) base floor covering and capable of adequately supporting live loads of _____ Kg/m^2. The floor shall be so constructed as to provide a holding depth of at least _____ cm for equipment anchoring devices.

10.3.5 Provided with a roof capable of supporting adequately a live load of ___ Kg/m^2.

10.3.6 Inside walls shall be smooth-surfaced and light-colored to permit maximum utilization of available light, and shall not be subject to damage under normal operational activities.

10.3.7 Buildings shall have a minimum inside dimension of ___ by ___ m, with a minimum inside floor-to-ceiling height of ___ m. Major equipment items shall be positioned as per a building floor plan to be designed by Offeror.

10.3.8 The building door shall be fitted with double doors on one face, and shall be located on building floor plan developed by Offeror. Door hinges shall be heavy duty and corrosion resistant, capable of holding seals tight under specified conditions. Door seals should be one piece, RF type for effective seal and to preclude EMI. The doors shall be equipped with a three point latch. The doors shall be provided with adequate tamper proof locking devices. The integrity of the door seal shall not be affected by the fastners. The door shall have a door stop and shall be provided with a device to hold the door closed while working inside. Means shall be provided to open the door from the inside. The door shall be flanged ___ cm completely around the door to ensure that hurricane force winds will not drive water or dust into building past door seal.

10.3.9 The door shall be equipped with a device to lock the door in the open position in order to prevent the door from being damaged by gusting wind. The door shall be equipped with a switch to provide contact closure when the door is open. Wiring from the switch shall be run through conduit to a position over the rack where fault-reporting equipment is located.

10.3.10 All exterior items being installed shall be sealed with G.E. Silicone Sealer, No. SE-1209, or approved equal.

10.4 Environmental Conditions

10.4.1 The building shall be equipped with a forced air electric heater, ventilation fan and air conditioner capable of maintaining the inside temperature under operating conditions, plus sensible and latent heat gain from people, at ___°C ± ___°C. These conditions to be met with service conditions previously specified in paragraph 10.2. No ventilation fan and the air conditioner shall be wired in such a way as to allow the simultaneous operation of both units. The ventilation fan shall be dampened against back thrust. Air intakes and exhausts shall be equipped with roden screens and an air filter.

10.4.2 Lighting shall be installed within the buildings, to provide ___ m candles at a height of plus ___ meters from finished floor. All components used shall be quality grade industrial lighting fixtures.

10.4.3 A thermostat shall be provided. An alarm consisting of a contact closure at room temperatures of more than ___°C and less than ___°C shall be provided, and connected to system alarm facilities.

10.5 Electrical Facilities

The Offeror shall supply a complete working electrical system for the building. The work shall include the delivery to the site of all labor, equipment and the performance of operations required for the installation of the complete electrical system.

10.5.1 The Offeror shall supply the following minimum equipment:

- 1 - ___ breaker ac distribution cabinet with ___ ampere main breaker
- 1 - ___ position ___ pole dc distribution fuse cabinet
- 1 - Air conditioner (floor mounted) EER Rating 10.0 minimum
- 1 - Ventilation fan with thermostat control
- 1 - Forced air electric heater
- _ - 125 volt ac convenience outlets
- _ - ___ watt incandescent bulb light fixtures
- 1 - Set air intake louvered vanes with fiberglass filter and bird - rodent screen
- 1 - Set of waveguide entrance ports, located as per design plan
- Cable ducts as required by floor plan design

° Honeywell Farm-O-Stat, (or approved equal) thermostat to be used as a radio building Hi/Lo temperature alarm

10.5.2 All equipment and materials furnished and installed shall be new in condition, and of the highest quality, and shall be standard products of manufacturers regularly engaged in the production of such equipment and materials, shall be the latest standard design, and shall bear the Underwriter's Laboratories Seal of Approval where applicable.

10.5.3 Installation shall comply with the latest National Electrical Code, anything in these specifications or drawings to the contrary notwithstanding.

10.5.4 Purchaser will supply electrical service to the building. This service will be 120/240 V, single phase, 3 wire, 60 Hz, ____A capacity.

10.5.5 The Offeror shall supply the building with an underground service in accordance with Article 230-24 (b) of the National Electrical Code.

10.5.6 A ___ cm rigid galvanized conduit, shall be used for the service entrance conductors and shall be firmly fixed to the building inside wall for attachment to ac distribution panel. Further, the conduit shall be sealed against moisture at its entry to the building.

10.5.7 The main power panel shall have a minimum rating of ____A, 120/240 VAC. It shall be furnished with properly sized circuit breakers for the loads to be supplied.

10.5.8 Branch circuits shall be so arranged that the 120/240 VAC service to the building is balanced, resulting in less than ___A neutral current.

10.5.9 All interior building wiring shall be in rigid electrical conduit or electrical metallic tubing. Articles 346 and 348 of the National Electrical Code shall apply.

10.5.10 Flexible metal conduit used shall be as covered by Article 350 of the National Electrical Code. Runs of flexible metallic tubing shall be as short as practical and shall terminate in proper connectors.

10.5.11 All conductors shall be properly sized for the load that they supply, but, shall be no smaller than #12 AWG. Conductors shall be copper, type THHN. Stranded conductors may be used when run in flexible metallic conduit.

10.5.12 Stranded wire shall use approved pressure connectors for splices and terminations.

10.5.13 Where wire nuts are used for splicing conductors, they shall be properly sized, preinsulated type spring connectors.

10.5.14 Conductors shall be continuous from outlet to outlet. Splices shall be made within outlet boxes or junction boxes only.

10.5.15 Duplex outlets shall be ____A, 125V, 3-wire grounding, heavy duty type.

10.5.16 The entire electrical system shall be checked after installation at the site and adjustments made to provide a proper working system.

10.5.17 A minimum of _____ convenience outlets shall be provided, typically located at ____ meter intervals on each wall, except where battery bank is located. Outlets shall be located in accordance with the design floor plan.

10.5.18 All wiring and cabling to the equipment racks shall be installed in an overhead raceways. The wiring will be supplied and connected by the Contractor as will the raceways.

10.5.19 All breakers, distribution centers, contactors, etc., shall be contained in NEMA Type 1 enclosures, and manufactured by Square D, General Electric, or approved equal.

10.5.20 All equipment and hardware installed in the building shall be done so in an acceptable craftsmanship manner. All wall mounted equipment shall present a neat symmetrical appearance and be installed in a highly stable and rigid manner.

10.5.21 All equipment to be installed in the building shall be of high quality design and recommended or approved for commercial application.

10.5.22 Building and accessories when finished shall be complete in every respect and ready for use intended. Preliminary drawings shall be submitted for approval.

10.5.23 The Contractor shall furnish two sets of manuals covering all electrical equipment supplied with the building. These manuals will contain schematic diagrams, maintenance instructions and parts list as required.

10.5.24 The communication equipment building shall be positioned so that the side of the building adjacent to the tower, shall not be located at a point within _____ meter of the base of the tower. This to preclude damage to the building from ice, or other debris, falling from the tower surfaces.

11.0 STATION BATTERY SYSTEM

11.1 General

The dc power shall be furnished and installed as indicated in this specification.

All electronic equipment shall operate directly from a dc power supply consisting of a float-charged battery and battery charger operated from the station's power source.

11.2 Battery

_____ storage batteries shall be provided, designed for communications use.

11.2.1 Ampere-Hour Capacity: The ampere-hour capacity of the battery at each station shall be sufficient to carry the load of that station, as determined on "Battery and Charger Calculation Work Sheets" to be furnished by the Offeror. The battery shall be capable of supplying the station load continuously for a period of __ hours with electrolyte temperature of ____°C.

11.2.2 Number of Cells: Twelve cells for 24 volt and twenty four cells for 48 volt operation of the proposed equipment.

11.2.3 Grids: Offeror shall specify the percentage of calcium content.

11.2.4 Specific Gravity: The specific gravity of each cell shall be 1.210 ± 1.115 at ___°C after full charge. The cell voltage shall be between 2.20 and 2.30 volts when battery is floated at 2.25 volt per cell average.

11.2.5 Operation: All batteries furnished will be operating at a float voltage 2.25 volt per cell. No periodic equalization shall be required. The charger shall regulate the voltage to the battery terminals within ± 0.5 percent. The Offeror shall state the recommended maintenance for the batteries proposed.

11.3 Battery Rack

Battery racks shall be of the two-tier type. Frames, rails, and braces shall be made of steel. The final finish shall be an acid-resistant enamel.

11.4 Battery Records

The Offeror shall record the initial readings for the bus and each cell in accordance with the battery manufacturer's recommended procedures. The readings shall be witnessed by the duly authorized Purchaser's representative.

11.5 Cell Numerals

Plastic cell numerals shall be fixed to each cell starting with the numeral "1" at the positive terminal. The succeeding numbers shall then follow the electric circuit, ending with the numeral "12" or "24" on the cell at the negative terminal. The size of the plastic numeral shall be at least ____ cm and no greater than ____ cm. Each battery shall be assigned a serial number, which shall be fixed to each cell along with cell number at the factory.

11.6 Float Voltage

Batteries shall be suitable for float charge at 2.25 volt per cell.

11.7 Battery Connections

Electrical connections to the cell terminals shall use lead-plated copper lugs or straps to eliminate corrosion.

Intercell cell connectors and cables connecting the battery to the battery charger and the battery to the dc distribution cabinet shall be sized to coordinate with the battery charger dc output fuse.

11.8 Battery Accessories

Each site battery system shall be equipped with the following accessories:

- Hydrometer with markings every 10 points
- Thermometer, Battery
- Connector bolt wrench
- One acid-resistant container for storing the hydrometer
- Lifting sling and spreader block
- OSHA approved emergency eyewash kit

11.9 Discharge Curves

The Offeror shall provide copies of the battery manufacturer's discharge curves for each type of cell proposed. These curves shall be included in the Offeror's technical proposal, with calculations used to determine the capacity of the proposed batteries.

11.10 Battery Chargers

The battery chargers supplied under this specification shall provide full-wave rectification by means of silicon controlled rectifiers. These chargers will be used for float charging lead-calcium storage batteries. They shall operate from a 240 volt, single phase, 60 Hz source.

11.11 Standards

The following standards and specifications form a part of these specifications and, unless otherwise specified, all chargers shall be manufactured and tested in accordance with the applicable requirements of the following standards:

- National Electrical Manufacturer's Association (NEMA), Standard for Semiconductor Rectifiers Safety Code, Publication No. MR 1-1958
- EIA Standard No RS-262, Semiconductor Rectifiers Diodes, Class of Service Environmental and Test Requirements (NEMA Publication No. UD-49-1962)

11.12 Temperature Rise

Under continuous conditions and at maximum rated output with an ambient temperature of 40°C, the temperature rise of any charger component, shall not exceed the maximum continuous operating thermal limit specified in the individual standards of IEEE, NEMA and the National Electrical Code.

11.13 Operation

Chargers shall be supplied with control equipment to make them completely automatic as to output current and self-regulating as to output voltage. The output voltage shall be continuously adjustable over the range of 23 to 28 volts for the 24 volt batteries and 46 to 58 volts for the 48 volt battery. Controls that have erratic response will not be acceptable.

11.14 Regulation

The output voltage shall be constant ± one-half percent under the following conditions:

- Load: For any load from no-load to full-load
- AC Input Voltage: The ac input voltage variation of ± 10 percent
- Frequency: A frequency variation of ± ___ percent
- Completely independent of the battery

11.15 Current Limiting

The Chargers shall be self-limiting as to load current. The charger circuitry shall be such that the charger does not rely on the blowing of fuses or breakers to limit the current except under the short-circuit conditions. Limiting shall occur at 115 percent of maximum rated output.

11.16 Protection

The Chargers shall be equipped with fuses or protective devices to protect the charger components during fault conditions on the dc side of the charger, as well as during internal faults. Such protective devices shall provide fault protection on both the ac input and the dc output of the charger. The ac protection shall be properly coordinated with the dc protection for faults on the dc bus.

11.17 High Voltage

A high voltage sensing circuit shall be provided which will deenergize the charger output whenever the output voltage exceeds a preset voltage. This voltage shall be adjustable over the range of at least 26 to 29 volts for 24 volt batteries and 52 to 58 volts for a 48 volt battery in increments of 0.2 volt or less.

11.18 Discharge

Battery chargers shall be so constructed that the battery will not be discharged through the charger components during an ac supply outage. The current through the voltmeter or pilot light will not be considered as being sufficient to discharge the battery.

11.19 Capacity

Each battery charger shall have sufficient capacity to carry the full station load plus additional capacity sufficient to recharge a fully discharged battery within 24 hours after restoration of commercial power. The Offeror shall demonstrate the ability to meet this requirement by means of voltage and current measurement tests to the Purchaser's duly authorized representative at the time of acceptance. The full load capacity of the charger shall be specified by the Offeror in his proposal.

11.20 Control

The following control and instruments shall be provided on each battery charger panel:

- AC supply ON-OFF switch or circuit breaker
- Output voltage selector switches, adjustable knobs, for the adjustment of float charge voltage

11.21 Instruments

A dc voltmeter with a scale length of not less than _____ cm, with an accuracy of 2 percent, shall be provided on each charger.

A dc moving coil ammeter with an accuracy to within 2 percent of full scale shall be provided on each charger.

11.22 Alarms

The following alarms shall be provided with each battery charger:

- DC High Voltage alarm, adjustable from 26 to 29 volts for 24 volt chargers and 52 to 58 volts for 48 volt chargers
- DC Low Voltage alarm, adjustable from 21 to 26 volts for 24 volt chargers and 42 to 52 volts for 48 volt chargers
- Charge failure alarm relay

11.23 Enclosure

The Chargers shall be housed in metal enclosures designed to allow ready access for maintenance. The enclosures shall have sufficient louvers for adequate ventilation. Knockouts shall be provided convenient for the supply and load circuits. Terminals shall not be exposed when all covers are in place.

11.24 Terminals

All terminal blocks shall have their terminals marked to facilitate the identification of the particular terminal on the wiring or schematic diagram.

11.25 Filter

The output ripple voltage of the charger connected to the battery only, shall not exceed 30 MV rms.

11.26 Transformer

The battery charger shall have an isolating transformer with a dual primary winding.

11.27 Efficiency

The efficiency of the battery charger, at its rated full load with the nominal input voltage, shall be ___ percent, or greater.

11.28 Automatic Load Disconnect

The charger system shall be equipped with a load disconnect that automatically disconnects the load when the battery voltage goes below 21 volts on the 24 volt systems and 42 volts on the 48 volt systems.

11.29 Equalizing

The charger system shall be equipped with a timer assembly to permit equalizing of the battery bank. Equalizing system shall be defined.

11.30 Mounting

The charger system shall be of the rack mounting type for a standard EIA, 19 inch rack. This rack shall be floor mounted with the top of the charger at least ___ meters above the floor.

11.31 DC Power Boards

The dc power panel shall be provided for the distribution of dc power. The panel shall be equipped with indicator type fuses, as required by the station load. Redundant or standby equipment, if any, shall be powered from separate fuses. The panel shall be rack-mounted.

11.32 Ground Bus

The power board shall be equipped with a ground bus. The bus shall be drilled and tapped to accept solderless connectors. The ground bus shall also be rack-mounted and grounded to the relay rack.

11.33 Battery and Charger Servicing

Facilities shall be provided to enable the batteries and chargers to be maintained without interruption of service.

One set of Operation and Maintenance manuals shall be provided for each site, with two sets provided for office files.

12.0 TOWERS

12.1 General

This specification covers the requirements for the supply, delivery, and installation for ___ microwave towers, complete with tower lighting, footings, lightning protection and painting.

The towers to be furnished may be either Self Supporting, Multiple Leg Towers, or Single Pedestal, Guyed Towers. The single factor for selection, for all towers meeting or exceeding the requirements of this specification, shall be the overall, "In Place" cost of the tower, with the option for selection resting entirely with the Purchaser.

The towers furnished under this specification are to be delivered and installed at the sites indicated and pricing associated with these towers will be accomplished on this basis.

Buildings to house the communications equipment at each of the sites are hereinafter specified under Section _____ Paragraph _____ of these specifications, but the Purchaser reserves the option to either purchase these buildings together with the towers furnished, or to purchase the buildings from another source. Bids for all buildings should be priced separately from the towers, so that the Purchaser may evaluate the costs associated with the buildings, and exercise his option for purchase of the buildings, if he so desires. The pricing for the buildings should include all costs associated with the supply, and erection of the buildings.

To assure compatibility and compliance with not only National Codes and Standards, but Local Codes and requirements as well, it shall be the responsibility of each Offeror to insure that emplacement and erection of all towers, is in compliance with Local Codes, where applicable.

12.2 Specifications and Standards

The following specifications and standards (latest revision) shall be considered to be part of this specification. In the event of conflict between the requirements of this specification and the requirements of the referenced documents, the requirements of this specification shall govern.

EIA Standard RS-222C: Structural standards for steel antenna towers and other supporting structures

AISC Manual of the American Institute of Steel Construction

Department of Transportation - Federal Aviation Administration Advisory Circular AC 70/7460-IC: Obstruction Marking and Lighting

Federal Communications Commission - Rules and Regulations Part 17: Construction, Marking, and Lighting of Antenna Structures

American Welding Society (AWS) - Structural Welding Code AWS D1.1-Rev. 77

American Iron and Steel Institute (AISI) - Specification for the design of cold-formed steel structural members

National Fire Protection Association (NFPA) - NEPA-70 National Electric Code (NEC)

Federal Regulation Guide (FRG) - Title 47 - Telecommunications
Chapter 1 - Federal Communications Commission

Rural Electrification Administration (REA) - REA Bulletin 66-8
Power Systems Communication: Mobile Radio Systems

Federal Aviation Agency (FAA) - Part 77 - Objects Affecting Navigable Airspace (14 CIR 77)

ASTM A-36: Specification for structural steel.

ASTM A-53: Welded and seamless steel pipe.

ASTM A123 Standard specification for zinc (hot galvanized) coatings on products fabricated from rolled, pressed and forged steel shapes; plates, bars, and strip.

ASTM A143 Recommended practice for safeguarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement.

ASTM A153 Standard specification for zinc coating (hot dip) on iron and steel hardware.

ASTM A325	Standard specification for high-strength bolts for structural steel joints, including suitable nuts and plain hardened steel washers.
ASTM A375	Carbon steel plates, shapes and bars of structural quality not over 4 inches in thickness for use in construction of welded structures.
ASTM A384	Safeguarding against warpage and distortion during hot dip galvanizing of steel assemblies.
ASTM A385	Recommended practice for providing high quality coatings (hot dip) on assembled products.
ASTM A386	Standard specification for zinc coating (hot dip) on assembled steel products.
ASTM A446	Standard specification for steel sheet zinc coated (galvanized) by the hot-dip physical (structural) quality.
ASTM A475-A476	Standard specification for zinc-coated steel wire strand.
ASTM A440	High strength steel shapes, plates, and bars of structural quality intended for use in the construction of riveted or bolted structures (up to 4 inches thickness).
ASTM A441	High strength, low alloy structural steel shapes, plates, and bars for welded, riveted or bolted construction (up to 8 inches thick).
ASTM A242	High strength, low alloy structural steel shapes, plates, and bars for welded, riveted or bolted construction.
ASTM A307	Low carbon, steel externally and internally threaded standard fasteners.

ASTM A475 Specification for steel wire strand (galvanized).

ASTM A572 High Strength, low alloy Columbium-Van Adium steel of structural quality.

12.3 Tower Sites

The geographical locations, site elevations, above mean sea level (AMSL), and estimated tower heights for the towers to be furnished under this specification are as follows:

Site Name
Longitude
Latitude
Site Elevation _____ meters AMSL
Tower Height

Site Name
Longitude
Latitude
Site Elevation _____ meters AMSL
Tower Height

Site Name
Longitude
Latitude
Site Elevation _____ meters AMSL
Tower Height

Etc.

12.4 Contractor's Responsibilities

The Contractor shall:

12.4.1 Accomplish all required concrete work for the tower footings and building foundations, where buildings are included in his offer, including the preparation of sites. No site grading or leveling will be done by the Contractor. Any site clearing required will be accomplished by the Purchaser.

12.4.2 Provide the Purchaser with proper technical data necessary for state and local building permits.

12.4.3 Provide the Purchaser with a project work schedule within thirty (30) days prior to start of construction. This will include all sites listed in Section 12.3.

12.4.4 Be responsible for any loss or damage to crops, or property outside the assigned tower areas caused by his operations or personnel. Damages will be settled with the owner of the

property by the Contractor in the company of an agent of the Purchaser. Any damages or losses of livestock shall be the Contractor's liability. The Contractor shall submit the signed damage releases for any tower site concerned before final payment is made.

12.4.5 Remove all excess construction material such as crafting, packaging, forms, empty paint cans, or other rubbish from all sites on completion of construction. All sites shall be neat and free of debris prior to final payment.

12.4.6 Provide F.C.C. and F.A.A. permits and licenses.

12.4.7 Provide all modifications needed in existing building.

12.4.8 Provide connections to or from Purchaser's alarm reporting system.

12.4.9 Provide all fences which Purchaser may deem necessary.

12.4.10 Provide a site plot plan showing location of buildings towers and orientation of the towers prior to the start of construction.

12.5 Purchaser's Responsibilities
Purchaser Will:

12.5.1 Obtain all right-of-way, easements and property for location of buildings, towers, access roads and driveways.

12.5.2 Provide commercial power, 120/240 volt, 60 Hz, single phase, 3 wire, ____ ampere, to all sites including existing sites.

12.5.3 Coordinate access for Contractor's personnel at all site locations.

12.5.4 Provide building permits.

12.5.5 Obtain all required, Federal, local and state permits, including zoning permits.

12.6 Design

12.6.1 Towers shall be designed and erected for a design wind load of ____ kilograms per square meter and _____ cm, solid, radial, rime ice, on the tower, antennas, guys and all appurtenances simultaneously. The horizontal wind pressure shall be as given in EIA RS-222C (Section 2.2).

12.6.2 Tower shall be designed, fabricated and erected according to the latest EIA RS-222C specification. Where there is a conflict in specifications, the most stringent shall apply.

12.6.3 The shaft of guyed towers shall be supported on a pivot mount at the center of the foundation in a manner to prevent transmission of bending forces between the tower and the concrete base.

12.6.4 The towers shall be designed to minimize additional stresses from eccentric connections. Stresses resulting from eccentricity shall be included in the design analysis.

12.6.5 A complete detailed structural analysis of each tower shall be submitted _____ days after award of Contract to enable the Purchaser to check compliance with these specifications. All tower designs including a detailed structural analysis must be approved and certified by a Registered, Professional Engineer licensed in the State of _____.

12.6.6 All antennas shall be laterally braced as recommended by the manufacturer and torsion stabilizers shall be provided for guyed towers as necessary to comply with this specification. No towers shall have a face width less than _____ meters.

12.6.7 All designs shall consider only bolted angular construction for the guyed or self-supporting type towers proposed.

12.6.8 The guy anchor shaft design shall permit the shaft to assume a direction in line with the resultant forces of the guys at any loading condition within the limits of this specification.

12.6.9 All towers shall conform to the minimum standards and requirements as outlined in EIA Standard RS-222C unless otherwise provided in these specifications.

12.6.10 Unit stresses shall be those referenced in EIA Standard RS-222C paragraph 3.

12.6.11 Guys shall have a factor of safety as determined and limited in EIA Standard RS-222C paragraph 8.

12.6.12 All components of towers and supporting elements shall be proportioned so that the unit stresses resulting from specified loads shall not exceed the allowable unit stresses of the "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" issued by the American Institute of Steel Construction.

12.6.13 All parts of the tower, except stainless steel, including the anchor rods with guy attachment plates, but not including the guys, shall be hot-dipped galvanized as specified under ASTM Designation A-123.

12.6.14 All tower hardware such as bolts, nuts, turnbuckles, guy clips, etc., shall be coated as specified in ASTM Designation A-153.

12.6.15 Anco lock nuts shall be used to secure all bolted connections and shall conform to EIA RS-222C (paragraph 1.1.5.2).

12.6.16 Structural steel shall be in accordance with current ASTM specifications for structural steel for bridges and buildings, designation: A36, A441, A440, A573, or A242, latest revision.

12.6.17 If welding is employed in fabrication at factory, it shall be x-ray quality and must conform to AISC and AWS standards.

12.6.18 Any members that are buckled or bent must be replaced. All base shoes must be level and grouted. All bolts must be drawn up tightly against the member, and the bolt will have a minimum of two threads protruding beyond the nut.

12.6.19 All guy strands shall conform to ASTM A475, with Class A zinc coating.

12.6.20 The factor of safety of guys and their connections shall not be less than 2.5 as defined by EIA RS-222C (Section 8.1).

12.6.21 Guy hardware shall be capable of developing full breaking strength of the guy strand. Crosby clips shall be used to terminate the guy cable.

12.6.22 Tower guys shall be one continuous piece of strand from the guy anchor points to the tower. Splicing of guy strand is not acceptable. All guy tensions shall be adjustable to recommended values, using a properly calibrated strand dynamometer, to within _____ percent of calculated design values under normal wind conditions.

12.6.23 Each guy shall be attached to the guy anchor plate by a separate fixture. One bolt or fixture shall not be used at the guy anchor plate to terminate two guy lines.

12.6.24 To provide maximum use of turnbuckles, they shall be fully extended when initially installed, except that one complete thread shall remain exposed inside buckle body. After guy tensioning has been completed, all turnbuckles shall be secured with a piece of guy wire through the turnbuckle body and eyebolt, with the ends secured together with crosby clip.

12.6.25 In pulling guy strand, the "Chicago" type grip is recommended. The jaw of the grip shall be of sufficient length to take full lay of the strand, and the inside jaw contour shall be designed to avoid strand damage. "Haven" type grips with serrated jaw will damage strand and shall not be used.

12.6.26 Guy anchor heads shall be a minimum of ____ cm above ground level. Splicing of anchor rods is not acceptable.

12.6.27 Guy crossing roadways or railroad tracks shall be arranged to have a minimum overhead clearance as follows:

- Roadway, ____ meters
- Railroad tracks, _____ meters

12.6.28 Templates shall be used to install anchor bolts in the concrete, and care shall be exercised to keep such inserts in position until concrete has set. The exposed threads of all concrete bolts shall be left clear of concrete.

12.6.29 Contractor shall protect all existing buildings, structures and equipment during the fabrication and erection of the tower from falling objects, including paint. Contractor shall be liable for any damage caused to such buildings and equipment.

12.6.30 Each design purposes, all towers shall be designed to mount ___ each, ____ meters diameter, standard performance, parabolic antennas (_____-East-West).

12.7 Footings and Foundations

12.7.1 Foundations and guy anchors shall be designed in accordance with EIA Standard RS-222C, Section 7 or latest revision thereof.

12.7.2 Soil testing, if required, will be performed by the Purchaser. The results of these tests will be forwarded to the Contractor and shall form the basis of his tower and foundation design. Assume ____ psf normal soil.

12.7.3 With the structure and antennas subjected to the design wind loading, the specified allowable soil bearing pressures and uplift resistance shown in EIA RS-222C, Section 7 shall not be exceeded.

12.7.4 The Contractor will furnish all necessary personnel, supervision, tools, equipment, materials and transportation required to complete the installation and erection of all items specified herein for purchase.

13.7.5 The Contractor shall provide all necessary services to haul, handle and unload the materials he is to furnish and install.

12.7.6 The Contractor shall furnish all necessary labor and equipment to locate the tower vertical center point, guy anchor, footing, and foundation positions.

12.7.7 Prior to start of construction, Purchaser shall review staking at the site. No work shall be done without Purchaser's approval. All submittal data must receive full approval of Purchaser before commencing tower erection.

12.8 Excavations

12.8.1 The natural earth at each site shall be disturbed as little as possible during construction. In all cases, the ground surface at each site shall be restored to the original grade level and completed reasonably smooth and compact.

12.8.2 Suitable excavated material shall be placed in back-fill or in graded embankment by the Contractor in the immediate vicinity of the towers, as directed by the Purchaser.

12.8.3 Foundations in earth shall be excavated to clean level surfaces of undisturbed material of adequate bearing value. Over excavation shall be backfill with a stone or gravel base material in ___ cm layers well compacted or shall be filled with concrete. In either case, the cost of the backfill or additional concrete used in the foundation shall be borne by the Contractor. Where water is encountered, the hole shall be kept dry by pumping during the installation of the foundation and during the backfilling process.

12.8.4 Where loose rock or boulders are encountered extending above the proper elevation of the concrete slab footings base, they shall be removed to a depth approximately ___ cm below the footing base. The resulting depression shall be backfilled with selected borrow well compacted to assure an even bed for bearing. The additional excavation and backfill so required shall be considered work incidental to the installation of the footing.

12.8.5 The stone or gravel base cited above shall consist of a mixture of graded aggregate, coarse and fine, together with soil binder.

12.8.6 Foundation excavations shall be maintained in a safe, clean and sound condition up to the time of placement of footings. All holes shall be protected when not attended. Whenever necessary, the Contractor shall re-excavate materials which have accumulated in previously prepared holes. Any unsatisfactory bearing material resulting from frost action or entrance of water into excavations shall be removed and replaced with well compacted stone or gravel backfill at the Contractor's expense.

12.8.7 The Contractor shall do all bracing, sheeting and shoring necessary to perform and protect all excavations as required for safety and to conform to laws and regulations of government bodies having jurisdiction. When sheeting is used, it shall be removed during or upon completion of backfilling.

12.8.8 Selected earth borrow shall be used as backfill material when the excavated material has been deemed unsuitable.

12.9 Concrete

12.9.1 All concrete for the work shall conform to the requirements of the latest edition of the "Building Code Requirements for Reinforced Concrete" of the American Concrete Institute, Designation ACI-318, except as modified herein, and to the latest revision of the following:

12.9.2 Standard Specification for Concrete Aggregate, ASTM Designation C33.

12.9.3 Standard Specification for Ready-Mixed Concrete, ASTM Designation C94.

12.9.4 Standard Specification for Air-Entrained Portland Cement, ASTM Designation C175.

12.9.5 Air-Entraining Portland Cement or approved equal shall be used.

12.9.6 Ready-Mixed Concrete shall be used for all work.

12.9.7 The concrete for tower foundations shall have a minimum compressive strength of _____ psi at ___ days and a minimum cement content of ____ bags per cubic yard of concrete. Slump for all concrete shall not exceed ___ cm and air entrainment shall be between __ and __ percent of the volume of concrete. The strength at ____ days shall be at least ___ percent of that specified for ____ days.

12.9.8 No concrete shall be placed until all form work, installation of parts to be embedded, and preparation of surfaces involved in the placing have been approved. No concrete shall be placed in water, except with permission of Purchaser and the method of depositing the concrete shall be prescribed by the Purchaser. Concrete shall not be placed in running water and shall not be subjected to the action of running water until the concrete has hardened.

12.9.9 All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, or with ice, mud or other foreign material shall be cleaned of all such refuse before the surrounding or adjacent concrete is placed.

12.9.10 Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and other foreign material.

12.9.11 The surfaces of concrete which have set, and against which new concrete is to be poured, shall be thoroughly cleaned to remove all foreign material and be saturated with water immediately before placing concrete. Concrete shall be deposited continuously and as rapidly as possible until the unit being poured is completed.

12.9.12 The temperature of concrete when being placed shall be:

- Not less than ___°C in moderate weather
- Not less than ___°C in weather during which the daily temperature drops below ____°C
- No greater than ____°C during hot weather

12.9.13 The Contractor shall protect all concrete against injury. Temperature shall be controlled by controlling the temperature of aggregate and mixing water. Mixing time should be kept at a minimum and elapsed time between mixing and placing should be minimized. The interior surfaces of forms and the ground upon which concrete is to be poured should be thoroughly wetted before the concrete is poured.

12.9.14 After the first frost, and until the mean daily temperature in the vicinity of the work falls below ___ °C for more than one day, the concrete shall be protected against freezing for not less than ___ hours after it is placed. Whenever the mean daily temperature in the vicinity of the work falls below ___ °C for more than one day, the concrete shall be maintained at a temperature not lower than ___ °C for at least ___ hours after it is placed and shall be protected against freezing for _____ days immedimately following the ___ hours of protection at ___ °C. Discontinuance of protection against freezing shall be such that the drop in temperature of any portion of the concrete shall be gradual and will not exceed ___ °C in ___ hours.

When the mean temperature rises above ___ °C for more than _____ successive days, the specified ___ hour protection at a temperature not lower than ___ °C may be discontinued, but the concrete shall be protected against freezing for not less than ___ hours after placing. When artificial heat is employed, special care shall be taken to prevent the concrete from drying.

12.9.15 Forms shall conform to the shape, lines and dimensions of the concrete as proposed and shall be sufficiently strong to carry the dead weight of the concrete without undue deflection or bulging, and sufficiently tight to prevent leakage of mortar. They shall be properly braced and tied together so as to maintain position and shape.

12.9.16 Reinforcing bars shall be made from intermediate grade, billet steel in accordance with the latest requirements of ASTM Designation A15. Deformations on reinforcing bars shall conform to the latest requirements of ASTM Designation A-305.

Reinforcing bars shall be accurately placed and secured in position so that they will not be displaced during the placing of the concrete, and special care shall be exercised to prevent any disturbance of the reinforcing bars in concrete that already have been placed. Rust-proof metal chairs, metal hangers, metal spacers, or other satisfactory metal supports may be used for supporting reinforcing bars. Precast concrete blocks may be used for supporting reinforcing bars.

12.9.17 The building footings shall be steel reinforced concrete having a minimum yield strength of ___ psi. A sufficient cap with anchor fittings shall be poured on the footing at the same time the footing is poured. If drilled foundations are used, the bottoms shall be belled out to a diameter of at least one foot greater than the diameter of the hole. In suitable solid rock, rock anchors set in grout in drilled holes may be used.

12.10 Structure Erection

12.10.1 Tower erection shall be in accordance with instructions issued with the design data.

12.10.2 Initial guy tension shall be achieved in accordance with instructions issued with the tower drawings.

12.10.3 All tower sections assembled on the ground shall be blocked off the ground using wood blocking so as to be free of dirt, mud and other foreign materials that tend to adhere to the structure. If erected by assembling in sections, initial bolting shall be adequate for dead load, live load and erection stresses, but shall not be so tight as to prevent aligning and fitting adjacent sections or members.

12.10.4 No work shall begin on the tower foundation until FCC-FAA construction permits have been obtained by the Purchaser. It is the responsibility of the tower contractor to obtain all local construction permits.

12.10.5 Tower foundations shall be allowed to cure for at least _____ days before placing or erecting the tower. No differential settling will be allowed in tower footings.

12.10.6 Correct length of bolts shall be used for all connections in accordance with the bolt assembly lists furnished by the tower manufacturer. Bolts shall be installed so that the nuts are on the outside or on top of the tower members. Bolts should be of such lengths as to protrude beyond the nuts a minimum of _____ cm and a maximum of _____ cm. All bolts shall be equipped with lock-nuts, lock washers, pal-nuts, or self-locking nuts. Misaligned holes requiring reaming must be completely filled by the use of a larger diameter bolt.

12.10.7 Mud, dirt, and other foreign matter shall be removed from the members before erection, with special attention given to cleaning the contact surfaces at joints before they are bolted together.

12.10.8 When portions of the tower are ground assembled, such assembly shall be on surfaces or blocking which will provide support to prevent distortion of tower steel and damage to surface finish. All bolts shall be installed in all connections of ground assembled portions of the tower. Temporary bracing of tower members shall be used to avoid overstressing or distortion.

12.10.9 The tower shall be erected plumb. The method of assembling and erecting shall be such that no member will be subjected during erecting to a load in excess of that for which it was designed. Extreme care shall be taken to establish and maintain the true geometric shape of the portion of the tower assembled. All connections must lay flat where they bolt together. No gaps between butt flanges or connections are acceptable after the bolts are tensioned.

12.10.10 Slings or other equipment used for picking up members or portions of towers shall be of such material or protected in such a way as to not cut into corners of the members, damage the finish, or distort or overstress members when heavy lifts are made. Members or portions of towers shall be raised in such a manner that no dragging on the ground or against portions of towers already erected will occur.

12.10.11 Members bent or distorted in handling may be used if they can be straightened without structurally damaging the metal. If bent members cannot be repaired to the satisfaction of the Purchaser, they shall be replaced. Any galvanized surfaces which are damaged for any reason shall be touched up with one coat of galvanized paint.

12.11 Painting

12.11.1 Towers shall be painted for aerial visibility marking in accordance with the Federal Aviation Administration's applicable regulations. The surface of all tower members shall have alternate bands of Aviation Orange and White paint furnished and painted before tower erection by the Contractor. After erection, all painted or galvanized surfaces marred during erection shall be repaired with paint or galvanize.

12.11.2 The Contractor shall prepare the surface to be painted so that it is clean and free of all dust, dirt, oil, grease, earth, moisture, loose rust, and loose scale and other undesirable residue immediately before the application of paint. Mechanical cleaning shall be used to remove solid residue such as rust and earth by scraping, wire brushing, or sanding until a sound metal or painted-surface remains. All paint shall be thoroughly mixed immediately prior to and during application. Paint shall not be applied to surfaces which are more than _____°C below air temperature. Paint shall not be applied in rain, fog, mist, snow, or when relative humidity exceeds _____ percent.

12.12 Lighting

12.12.1 Obstruction lighting shall be furnished and installed on new towers at elevations in accordance with the Federal Aviation Administration's applicable regulations.

12.12.2 The Contractor shall furnish, install, wire and connect on the tower all necessary conduit, junction boxes, obstruction lighting, fixtures, automatic controls, flasher and alarm relays with weatherproof enclosures. The Contractor shall bring all wires and make all necessary connections to the building distribution panel for all tower and building equipment. The 120/240 volt, single phase, 3 wire power supply to the building distribution panel will be supplied and connected by the Purchaser.

12.12.3 The obstruction lighting system shall consist of the following items supplied at each tower.

- A photoelectric device to turn tower lights on and off in accordance with FAA regulations
- A flashing device for turning code beacons on and off in accordance with FAA regulations. Failure of the flasher shall cause the code beacons to burn continuously
- Normally closed alarm contacts supervised by the photoelectric device shall be provided to indicate by their opening that one or more of either the code beacons, beacon flasher or side lights have failed. Sidelights and code beacon with flasher shall have separate alarm contacts. The photoelectric device supervision is to be provided for the exclusion of daylight alarming.
- Obstruction beam lighting fixture, 300 mm, red hazard Fresnel lens, two 620 watt lamps wired in parallel mounted to provide 260 degree horizontal visibility
- Two continuously burning sidelights at each elevation required by the FAA for each tower
- All bulbs shall be the long life (3000 hour) type or better
- A lightning arrestor protector shall be provided for the sidelight circuit and the obstruction beacon circuit

12.12.4 The Contractor shall provide temporary obstruction lighting during tower erection as required by the FAA construction permit. Source of temporary electric power for this purpose shall be taken from 120/240 volt service provided by Purchaser.

12.13 Grounding

12.13.1 All ground rods and ground wires shall be in accordance with EIA RS-222C. The top of ground rods shall be no more than _____ cm below grade.

12.13.2 A heavy-duty lightning rod shall be securely attached to the top of each tower.

12.13.3 Where towers and equipment are next to a high voltage substation, all inputs and outputs must meet the requirements of the IEEE surge wave test. Tower and building grounding must be designed to protect against ground potential rise between the substation and equipment installation.

12.14 Transmission Line Bridges

Transmission line bridges and ice guards shall be furnished over all horizontal waveguide runs. All material used shall be galvanized or rustproof and shall be painted.

12.15 Ladders

All towers shall be equipped with climbing ladders inside the tower with a minimum _____ cm step length and a maximum step separation of _____ cm. A climbing safety device shall be included with the ladder and shall meet the design requirements of the American National Standards Institute (ANSI) A14-3, "Safety Code for Fixed Ladders."

12.16 Tower Drawings, Design Analysis & Instructions

12.16.1 Preliminary Drawings: The Contractor shall furnish two copies of the following drawings and instructions:

- Preliminary design drawings for all towers, showing location of attachments, supports, and base plates
- Preliminary design drawings of antenna support members
- Preliminary design drawings of guy anchors, foundations, reinforcing steel, etc.

12.16.2 Approval Drawings: The Contractor shall furnish two copies of all drawings to purchaser for approval before placing the work in the shop. Such drawings shall be submitted as soon as possible after the issuance of the

"Preliminary" drawings mentioned above and shall, if at all possible, be the same drawings.

The Contractor shall furnish three print copies of all assembly and adjustment instructions for towers, including proposed method of achieving initial tension in guys.

12.17 Material Certification

Contractor shall provide certified mill test reports, certified reports of test reports, certified reports of tests made by the fabricator or a testing laboratory or an affidavit stating that all material furnished meets the requirements of the applicable referenced specification.

12.18 Inspection

The Contractor shall carefully inspect the entire tower to be sure of full compliance with the specifications and to avoid returning to the site for corrections. Special emphasis shall be placed on locking devices, all nuts being perfectly tight, complete tower markings, guy properly tensioned and served, tower plumb, and tower twist. The tower site shall be cleared of all cans, guy wire ends, boxes, crates, rubbish and other surplus materials incident to the work.

13.0 INSTALLATION

13.1 General

All radio equipment, any towers or buildings included, and all other materials shall be installed by the Contractor in a neat and professional manner, employing the highest standard of workmanship and in compliance with the National Electrical Code, Electronic Industry Association (EIA) standards, local building codes, applicable FCC of FAA standards and procedures, and standard construction procedures.

13.2 Specific

The Offeror shall furnish all equipment, materials, and services as required to provide a complete and functional system as described by these plans and specifications. Work at each site shall include, but not be limited to the following. All work shall be in compliance with the applicable drawings and/or specification requirements. In accomplishing installation, the Contractor shall:

- Extend temporary electrical service from fusible disconnect on power service pole. Pole and service riser shall be furnished by the Purchaser
- Stake tower base and guy anchor locations
- Install tower foundations and guy point anchors as required. Included shall be any fill or equipment required to gain access to the foundation locations
- Prepare grade for equipment building slab foundation and construct slab. Included shall be sleeves, conduit, etc., as required for power, grounding, and signal cable
- Erect tower and install tower lights (if used)
- Install station signal grounding system
- Erect communication equipment building
- Furnish and install permanent electrical wire service, and cabling in building
- Complete final installation of tower lighting system. Connect tower lights to lighting control unit

- Bond building grounding system to station ground
- Install lightning protection equipment
- Install antenna systems
- Install communication equipment and all power and signal cables extending to adjacent racks in overhead mounted raceways or cable trays supported from the ceiling of the equipment building. Furnish and install raceways as required
- Install ground bonds between communication equipment and station signal ground
- Install all inter-rack and communication equipment wiring
- Install such other facilities as required by these specifications

During the entire installation phases, it shall be the responsibility of the Contractor to coordinate all construction and installation activities with the Engineer to assure rapid and effective realization of the system to be furnished under these specifications.

14.0 TESTING

14.1 General

Buildings, towers, communication equipment plus other equipment and materials included in these specifications will be inspected and tested as appropriate by the Purchaser and the Engineer. The inspections and testing as specified herein will be conducted during the delivery and installation phases of the project, with final acceptance testing to be conducted at such time as the Contractor states that the system installation is complete, and ready for test.

The tests will be conducted to verify that all equipment called for by these specifications has been engineered, furnished and installed as specified, is functioning as called for, and that all work specified has been completed in accordance with the Purchaser's requirements.

14.2 Test Schedule

The Contractor shall provide the Purchaser with advance notification of tests to be conducted as follows:

- Factory Testing - ___ weeks
- Field Tests - ___ weeks

Field tests shall be conducted on subsystems by the Contractor on a basis to be specified by the Purchaser subsequent to contract award.

14.3 Test Procedures

Prior to initiating any tests, the Contractor shall develop a system test procedure and format for test documentation. It shall be the intent to allow the Contractor maximum flexibility in establishing test procedures in order to use procedures and practices familiar to the Contractor. If these procedures and practices are not acceptable to the Engineer, the procedures and practices established by the Engineer shall be used.

Prior to witnessing of field acceptance test by the Engineer, the Contractor shall conduct tests and record data for review and evaluation by the Engineer. The Contractor shall verify in writing that the system is ready for acceptance testing and that all facilities and systems are in compliance with the plans and specifications.

14.4 Retest Requirements

In the event that any facility is found to be deficient, or any communication test does not meet or satisfy the requirements of the specification for the test, action, as directed by the Purchaser's Engineer, shall be taken by the Contractor to correct the deficiencies noted, prior to

additional system testing. Tests shall be conducted, as required, until the deficiencies are corrected, and the system is operationally acceptable.

14.5 Test Equipment

It shall be the responsibility of the Contractor to furnish all equipment required to conduct system tests. All equipment shall be calibrated and calibration data made available to the Engineer upon request.

Prior to initiation of acceptance tests, the Contractor shall submit a list of test equipment (by types) to be used. Equipment shall be as referenced in the Test Procedures.

Types, model numbers and serial numbers of specific equipment used for system testing shall be included with each station test report.

14.6 Factory Testing

Factory tests shall be conducted by the Contractor and witnessed by the Engineer. It is desirable to conduct all tests consecutively for the entire system; however, subsystem tests will be acceptable if required to expedite completion of the project. Tests shall include all items as noted herein.

Factory tests shall be conducted with levels and adjustments set for nominal conditions expected in the field.

Factory test data shall be submitted to the Engineer for review and record purposes. If requested, sample tests shall be witnessed by the Engineer at no additional cost to the Purchaser.

14.6.1 The radio equipment shall be assembled at the Contractor's factory, where tests shall be performed on the individual equipment.

14.6.2 Contractor shall notify Purchaser at least _____ days prior to final factory testing and shipment to allow engineer and/or his representative to witness final testing of the equipment to be supplied.

14.6.3 Data recorded during factory testing will be compared with data obtained during field testing.

Offerors are to describe, in detail, their standard factory testing procedures and practices for each type of electronic equipment offered.

14.6.4 Contractor shall submit the factory test plan within _____ days after contract award for review and approval.

14.7 Field Tests

During the checkout and field testing, the Purchaser shall assign personnel to participate with the Contractor in the checkout of the system. A notification of _____ working days shall be given to engineer to allow for possible assignment of Purchaser's personnel. Offerors are to explain, in detail, their standard field testing practices and procedures for all equipment offered. The Contractor shall submit within 60 days of contract award a field test plan for review and approval.

14.7.1 Documentation

Data obtained during the field testing shall be fully documented, with the original copies of the documentation furnished to the Purchaser. The documentation shall include as a minimum, the following information:

- Site Name
- Test equipment utilized
- Proper equipment levels in accordance with Contractor supplied block and level diagrams
- Proper and effective operation of relay facilities and mobile units

Data recorded during these tests shall be checked against that obtained during factory tests.

14.7.2 If guaranteed performance is not substantiated by the tests, necessary corrections will be made, and, upon completion thereof, demonstrate to engineer that corrections have improved operation to the point that performance guarantees are obtainable.

14.8 Performance Tests

14.8.1 DC System Tests

The chargers and dc power boards shall be tested and adjusted to verify the following:

- Float voltage
- Charger operation
- Current limiting
- Meter accuracy
- Output ripple
- High-voltage trip and alarm
- Low-voltage switch operation
- Manual disconnect switch operation

The batteries shall be tested to verify the following:

- Cell voltage
- Cell specific gravity
- Battery bank voltage

The chargers shall be disabled for one hour and the above tests shall be performed again to check for defective cells in the battery bank.

14.8.2 Antenna Tests

All transmission lines shall have been tested by the antenna system manufacturer, for return loss (VSWR) utilizing a reflectometer technique. VSWR shall not exceed _____ for the complete antenna system.

Antenna gain tests shall be conducted to insure stated manufacturer's performance.

14.8.3 Radio System Tests

14.8.3.1 Field strength measurements shall be performed at each site and the following information recorded:

- Transmitter output
- Receive carrier
- Signal level contours

14.8.3.2 The field strength measurement on any contour interval shall not exceed the calculated value by more than _____ dB. Received carrier shall be measured during the substitution technique.

14.8.3.3 Intermodulation tests shall be performed on a link and subsystem basis.

14.8.3.4 Frequency response tests shall be performed on all equipment.

14.8.3.5 The AGC voltage vs receiver carrier shall be tested and recorded.

The receiver squelch shall be tested to assure squelch at level in specification.

14.8.4 Fault Alarms

14.8.4.1 The fault alarm system shall be tested at both the remote relay sites and the base station. Alarms will be simulated by jumpering of the contacts or other similar method.

14.8.4.2 The site transmitters shall be tested for proper transmit levels, with each fault point tested by simulating a fault. A check shall be made to verify that the proper alarm indicator on the transmitter is activated and that the fault is reported properly at the master station.

14.8.4.3 The audible and visual alarms at the base receiver station shall be tested.

14.8.5 Sensing and Alarm Circuits (Radio)

14.8.5.1 All sensing circuits, in the radio shall be tested for proper operation. Range of all variable devices shall be tested to assure that reserve adjustment is available, if required. Equipment failure and fuse alarms shall be tested and checked to verify that the proper point on the fault alarm is activated and the required visual and/or audible alarms occur.

14.8.5.2 All meter indications shall be tested to assure proper function. Range of adjustments for meter indication shall be tested.

14.8.6 On Site Inspections and Tests

All facilities and communication equipment shall be inspected and tested to insure compliance with the plans and specifications. This shall include, but not be limited to the following:

- AC power systems
- DC power systems
- Emergency generator
- Building HVAC systems
- Alarm system
- Pressurization system
- Tower lights
- Tower
- Grounding system
- Cable terminations and protectors
- Station licenses
- Antenna system
- Antenna system VSWR
- v.f. channels

14.8.7 Station Tests

14.8.7.1 Each base station and relay facility shall be tested to verify compliance with the plans and specifications. Tests shall include, but not be limited to the following:

- Transmitter frequency
- Transmitter power
- Nominal receive level
- IF output
- Noise measurements
- Squelch level
- Intermodulation distortion level
- Transmission line loss

14.8.7.2 Where applicable, results of tests shall equal or exceed specified, and Contractor supplied performance data. Link tests shall be witnessed by the Engineer.

14.9 System Acceptance

14.9.1 General

Acceptance of the Communications System shall be on a system basis. _____ days prior to completion of the system, the Contractor shall notify the Purchaser. This will allow a coordinated inspection, testing and acceptance schedule to be organized by the Contractor and the Purchaser.

14.9.2 Acceptance Criteria

Buildings, towers, and equipment will be accepted if by physical observation the facilities satisfy the intended requirements of the plans and specifications.

Communication equipment will be accepted if the physical equipment is furnished and installed in accordance with the specifications and the communication or electrical performance characteristics of these specifications are satisfied.

Upon compliance with plans and specifications, the entire system or subsystems will be accepted as complete as determined by the Purchaser and the Engineer.

14.9.3 Station and System Acceptance

Owner reserves the right to perform or have performed by the Contractor any testing to verify system specifications. Acceptance of part of any system will not obligate Purchaser to accept remaining parts of the system. Warranties shall not commence until final system acceptance.

The Purchaser will not make final payment to Contractor until the Purchaser's Engineer has certified that the communications system furnished and tested by the Contractor is operating in conformance with specifications and guarantees.

15.0 DOCUMENTATION

15.1 Within ____ days subsequent to date of contract award, the contractor shall furnish for Purchaser approval, a minimum of ___ sets of preliminary systems drawings and documentation consisting as a minimum of the following:

15.1.1 A key or index sheets listing in a numerical sequence all drawings and descriptive literature.

15.1.2 Rack elevations showing rack dimensions on all equipment units and their location on the racks.

15.1.3 _____ operational instruction books, including schematic diagrams for each different type of unit furnished shall be sent with the preliminary drawings to facilitate interpretation and approval of the drawings.

15.1.4 Operational block diagrams covering system function, alarm system and signal flow.

15.1.5 Manufacturer's assembly and installation drawings for antennas.

15.1.6 Communication equipment building physical layouts and structural drawings with dimensions. Included shall be drawings and descriptive data on all equipment included as part of the equipment building.

15.1.7 Drawings showing physical mounting details of all equipment and hardware furnished.

15.1.8 Details on station and equipment grounding.

15.1.9 Detailed building wiring drawings showing wire sizes and runs.

15.1.10 Wiring harness drawings and cable running lists for all racks, to include wiring of all plug-in shelf assemblies, showing wiring connections between units on a shelf and inter-rack wiring. Where vendor standard wiring assemblies are used, they shall be marked or otherwise cross-referenced to indicate applicable options and strappings. Units wired but not equipped shall be so indicated. External connections to all racks. All external connections, such as for power, alarm, audio, etc., shall be cross-referenced on the key or indexed sheets.

15.2 The Contractor shall furnish for approval, within ____ days after the contract award, his proposed system test procedures.

15.3 The Purchaser will, within _____ days after receipt of prints of drawings and design analysis for approval, forward one copy of each to the Contractor marked with one of the following:

15.3.1 Approved: Prints so marked will authorize the Contractor to proceed with the fabrication of the equipment.

15.3.2 Approved With Corrections: Prints so marked will authorize the Contractor to proceed with the fabrication of the equipment in accordance with indicated corrections. The Contractor shall make the necessary drawing revisions.

15.3.3 Returned for Correction: The Contractor shall make the necessary corrections and revisions on the drawings as indicated and shall resubmit prints for approval. Time required for such revision of drawings and resubmission of prints will not entitle the Contractor to any extension of time.

15.3.4 Work accomplished, or materials ordered, by the Contractor, prior to receipt of prints marked Approved or Approved With Corrections As Noted, shall be at the Contractor's risk. Approval by the Purchaser shall not relieve the Contractor of the responsibility for the correctness of the drawings furnished by the Contractor nor for their compliance with the specifications.

15.4 The Contractor shall furnish, within _____ days after system cutover the following documentation and manuals:

15.4.1 _____ sets of Instruction Manuals, covering the mobile radio equipment, incorporating, as a minimum the following information:

15.4.1.1 Complete system installation, operating, and line-up instructions.

15.4.1.2 Instructions for each different equipment unit furnished, including operating and maintenance instructions, parts lists, and schematic diagrams.

15.4.1.3 For units not manufactured by the radio equipment supplier, the manufacturer's name and his identifying part number shall also be furnished.

15.4.1.4 Operational block diagrams covering all system functions.

15.4.2 One set of Instruction Manuals per station covering the battery chargers, air conditioners if being furnished, and test instruments incorporating the following information:

15.4.2.1 Complete installation, operating, maintenance, and line-up instructions.

15.4.2.2 Complete schematic and wiring diagrams.

15.4.2.3 Complete parts lists.

15.5 The Contractor shall supply for each site, _____ copies of a certified factory test report. This test report shall contain data and meter readings taken during final factory alignment of equipment. No equipment will be acceptable which has a reading or readings not within the stipulated and agreeded upon tolerances listed in the instruction book. The test report shall contain overall system performance data to indicate compliance with all system tests. Three copies of system test reports containing the overall system performance data of the system field tests shall be furnished within ____ days after completion of tests.

15.6 The Contractor shall prepare a set of "as-built" drawings and submit these to the Purchaser's Engineer for final approval.

15.7 The successful Contractor shall be responsible for placing the Purchaser's name and address on the mailing lists of the manufacturers of all items furnished under these specifications, so that the Purchaser may receive all literature and data associated with any design modifications or alterations made by the manufacturers subsequent to the acceptance of the system by the Purchaser, and for a period of ____ years.

16.0 SPARE PARTS AND TEST EQUIPMENT

16.1 General

This section describes the requirements for spare parts and test equipment for the operation and maintenance of the system to be furnished. Parts, modules and test equipment to be recommended by the Offeror, but not manufactured by him, shall be indicated as such, and the manufacturer of the item stipulated. Common parts such as transistors, diodes, etc., that are available from more than one source shall be shown as such and the manufacturer's name will not be required.

The unit price of each item of Offeror manufactured test equipment shall be shown, indicating any discount advantage obtained by purchasing the test equipment from the Offeror at the time the system is ordered.

16.2 Spare Parts and Modules

A recommended spare parts list for the first year of operation on the system shall be provided. The spare parts list shall include prices of the individual modules, sub-assemblies, or spare parts as itemized and the total spare parts cost shall be given as required in this specification. Spare parts or sub-assemblies for the following shall be provided:

- Battery equipment
- Radio equipment
- Antenna system
- Alarm system

Spares for the equipment shall be recommended at the module level of repair and maintenance. This shall include sub-assemblies, modules and plug-in units.

Facilities available for return of units, subsystem, sub-assemblies and modules to the manufacturer for repair shall be described by the Offeror. The turn around time, for shipping the unit in for repair, and return, shall be stated by the Contractor.

Spare parts and modules shall be available for _____ years after acceptance of the system by the Purchaser.

16.3 Test Equipment

A list of test equipment required for maintenance of the proposed system shall be provided. It shall indicate the suggested minimum amounts and types of equipment required for proper maintenance. In addition, test equipment should be recommended to perform complete equipment alignment, testing and repair. If test equipment is of other manufacture than by the Contractor, it shall be so indicated.

17.0 TRAINING

17.1 General

The Offeror shall conduct a complete maintenance and operation training program for up to four persons. This program shall consist of at least ____ hours of instruction, including the general theory of operation of the radio, and other associated equipment. Test procedures to be followed in keeping the equipment in operating condition, emergency procedures, and routine maintenance acts shall include actual adjusting and testing of equipment furnished to the Purchaser on other equipment of the same type.

The Offeror shall submit costs for training to be conducted at the factory or at the Purchaser's location.

Training and instruction for the equipment shall be provided for the Purchaser's maintenance personnel to enable them to become familiar with the equipment supplied by the Contractor. In addition, the Contractor shall furnish educational material for dissemination to customers, covering the function and operation of equipment located on the customer premises. There shall be a maximum of _____ training sessions of _____ days each.

17.2 Classroom Training

The Offeror shall state in his proposal if factory training is available to Purchaser's personnel, and shall provide the curriculum cost of such training with his proposal.

17.3 On-the-Job Training

The successful Contractor shall provide on-the-job training (on an informal basis) for Purchaser's operating and service personnel in equipment operation and maintenance of the actual equipment installed. This on-the-job training shall be done concurrently with the installation and initial field testing of the communications system.

As part of his response, the Offeror shall state the number of personnel, and their qualifications as instructors that he will use to train, _____ radio technicians in the testing and maintenance of the equipment.

This on-the-job training shall include all of the communications equipment supplied under this specification.

18.0 MAINTENANCE AND MAINTENANCE RECORDS

The Contractor shall maintain the installed equipment from the time of equipment installation to the time of system acceptance. Maintenance shall be such as to maintain equipment to the performance levels as specified within.

If the Purchaser so elects, a maintenance contract shall be developed to extend maintenance for a period of one year from the date of system acceptance. During this period, the system shall be maintained at a level of performance as specified herein. At the termination of the first years contract, the Contractor shall conduct tests, set levels, and correct deficiencies as required to establish performance level of the system to the specifications contained herein. Test procedures as developed for the initial system tests shall be used and results documented.

Maintenance by the Contractor will be in accordance with these requirements:

- Replacement parts shall be at least of equal quality and ratings as the original parts
- Any water, oil, dust, or other foreign substance will be removed from the equipment, its parts and attachments
- Performance of the equipment will be kept at the level stated in the Purchaser's performance specifications
- Routine maintenance procedures prescribed or recommended by the Contractor for his equipment shall be followed
- The Contractor shall provide only factory trained and authorized maintenance personnel
- The Contractor shall supply comprehensive installation and maintenance manuals as part of this equipment purchase
- Service shall be provided on a 24-hour emergency call basis with on-site response within four hours after call

If there is any discrepancy between the maintenance obligations of the Contractor as represented by the standards of maintenance set out herein, the Contractor's Maintenance Agreement, the bid documents, or the proposal, the maintenance

obligations and standards most favorable to the Purchaser shall apply. The Contractor shall keep accurate records of all maintenance performed on each piece of equipment identified by serial number, including routine or preventive maintenance and emergency repairs, and shall make all records available for inspection by the Purchaser or his designee at any time upon reasonable request.

APPENDIX A

Radio Equipment Design Data

RADIO EQUIPMENT DESIGN DATA

RF Carrier Frequency _____

Transmitter:

- Power Output _____
- Output Impedance _____
- Modulation _____
- Frequency Stability _____
- Spurious Emissions _____
- Harmonic Emission _____
- Audio Sensitivity _____
- FM Noise _____
- Audio Response _____
- Audio Distortion _____

Receiver:

- Channel Spacing _____
- Modulation Acceptance _____
- Selectivity _____
- Spurious Rejection _____
- Image Rejection _____
- Frequency Stability _____
- Sensitivity (20 dB Quieting) _____
- Sensitivity (EIA SINAD) _____
- Noise Squelch Sensitivity _____
- Tone-Coded Squelch Sensitivity _____
- Intermodulation _____
- Audio Output _____
- Audio Distortion _____
- Audio Response _____

Antenna:

Type	_____
Gain	_____
Front-to-Back Ratio	_____
Lightning Protection	_____
Wind Survival	_____
Construction Material	_____
Termination	_____
Pattern Data	

APPENDIX B

Site Survey and Data Summary Sheets

Site Name and Number_____

Latitude_____ Longitude_____ (Degrees, Min, Sec)

Map reference (most detailed topographic)_____

Nearest town (Post Office)_____

Access route: (all Year?)

Property owner; local contact:

Site sketch _____ Site photograph _____ General description _____

Reference baseline _____ By Polaris _____ Other _____

Antenna No. _____ True bearing _____

Ground elev. MSL _____

Power availability:

a. Nearest transmission line _____ b. Voltage _____

c. Frequency _____ d. Phase _____ e. Operating utility _____

Drinking water source _____ Estimated depth to groundwater _____ Sewage disposal _____ Type and depth of soil on and near site _____

Nearest airport _____ railroad _____ highway _____

navigable river _____

Local communications facilities: telephone _____

telegraph _____ radio _____

Nearby radio transmitters _____ relay stations _____

Other interference sources _____

Local transportation facilities: airlines _____ railroads _____

truck _____ bus _____

Warehouse and storage facilities _____

Local suppliers (hardware, lumber, concrete, etc.) _____

Local contractors _____

Fuel sources (oil, gas, propane) _____

Local housing accommodations: temporary _____ permanent _____

Meteorological data from local sources: (averages for each month)

Maximum/minimum temperature (daily) _____

Precipitation _____ (Also extreme 1- and 24-hour)

Snow depth _____ (Also maximum for period of record)

Prevailing wind direction and speed _____

Extreme wind gust and direction _____

Dewpoint or relative humidity (mean diurnal change) _____.

DATE:		OBSERVER:	
SITE NAME AND NUMBER:			
LOCATION:	SECTION	TOWN	RANGE
COUNTY	STATE		COUNTRY
REFERENCE MAPS:			
DESCRIPTION:			
ACCESS ROUTE:			
SITE LOCATION SKETCH (NOT NECESSARILY TO SCALE)			

SITE INFORMATION WORKSHEET

Site Name & Antenna Designation	Site & Antenna Abbreviation	Latitude	Longitude	Tower Base Elevation above m.s.l. (m)

Site Location Summary Worksheet

APPENDIX C

Link System Gain Computation

Worksheets

TABLE C-1 Net System Gain Computation

Frequency _____MHz
CM 3 Signal Level _____dB**

Azimuth _____

		TALK-OUT				TALK-BACK				
		Urban		Suburban		Urban		Suburban		See
	Units	90%	68%	90%	68%	90%	68%	90%	68%	Figure*
SYSTEM GAINS										
1. Transmitter Power	dBw									II-51
2. Antenna Gain - Base	dBd									Spec sheets
3. Antenna Gain - Mobile	dBq									Spec sheets
4. Receiver Sensitivity - Effective	dBw									II-52
5. Total Gains	dB									
SYSTEM LOSSES										
6. Transmission Line	dB					1	1	1	1	II-31
7. Connectors	dB	1	1	1	1	0	0	0	0	
8. Transmitter Combiner - Base	dB									Spec sheets
9. Receiver Multicoupler - Base	dB									Spec sheets
10. Mobile Duplexer	dB									Spec sheets
11. Building Loss	dB									II-53
12. Foliage Loss	dB									II-16
13. Shadow Loss	dB									II-15
14. Portable Differential	dB									II-54
15. Margin	dB									II-55
16. Total Losses	dB									
NET SYSTEM GAIN	dBw									

*See Figure II-18 - REA Bulletin 66-8
**See Figure II-18 - REA Bulletin 66-8

TABLE C-2 Coverage Computation

Base Antenna Height		Units	Talk-Out				Talk-Back			
			Urban		Suburban		Urban		Suburban	
			90%	68%	90%	68%	90%	68%	90%	68%
100'	Net System Gain	dBw								
	Range	miles								

*U.S. GOVERNMENT PRINTING OFFICE: 1981-0-720-007/5904